1974 ANNUAL INDEX

Abbreviations: (TA) - Technical Article, (N) - News, (FP) - Feature Product, (SR) - Staff Report.

JANUARY
1974

MICROWAVES

laser technology

Land-Mobile Communications

Spectrum Limitations Challenge Microwave Designers

BALLOONS EXTEND REPEATER RANGE

SPECIALIZED COMMON CARRIERS: BOOM FOR COMMUNICATIONS EQUIPMENT MANUFACTURERS

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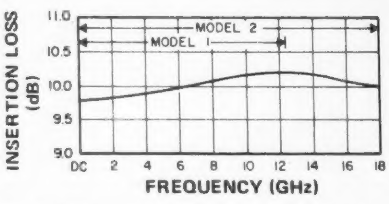

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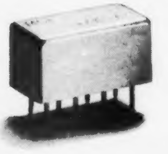

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For other Mini-Circuits Lab. products, see ads on p. 43 and 45


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MCM'S

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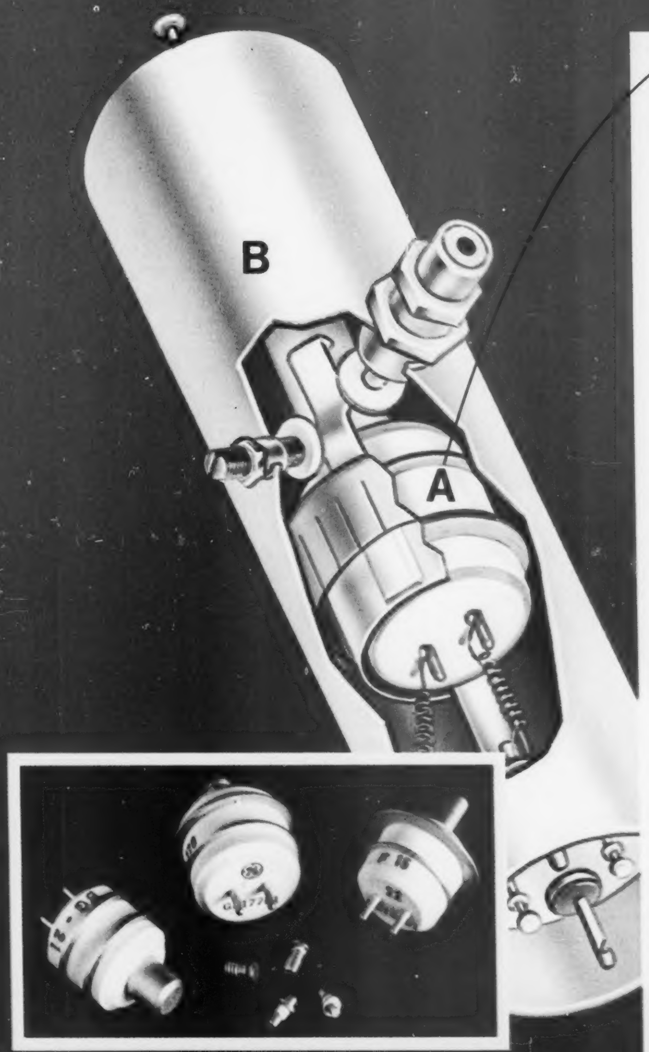

A GE Planar Ceramic Triodes deliver acknowledged state-of-the-art performance: thirty years' GE tube research with triodes has resulted in exceptional tolerance to the most adverse thermal, shock and vibration environments; very high ratio of power, efficiency, reliability and gain bandwidth to product size and weight; fast warmup; lower noise levels; and more efficient operation at higher frequencies.

And we've put our extensive knowledge of triode technology to work developing a family of prepackaged microwave circuits called General Electric MCM's (Microwave Circuit Modules) **B**— each built around a GE triode or solid-state diode. And each MCM is built with such care and precision that it, too, is fast becoming a recognized standard of excellence.

Functioning as an oscillator, an amplifier, or as a complete assembly (with a power supply, and/or integrated isolator/circulator, and/or modulator), GE MCM's solve five of your toughest problems:

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*In a recent Brand Recognition Study by a leading business publication, more designers expressed a preference for General Electric Planar Ceramic Triodes . . . 11% more chose GE over the next leading brand. (Copies of the Study are available upon request.) 360-09

GENERAL ELECTRIC

MICROWAVES

January 1974
Vol. 13, No. 1

news

technical section

products

departments

About the cover: Motorola's Dynatac portable telephone is a prime example of the new equipment being designed for the 900-MHz mobile radio band. Photo of portable telephone courtesy of Motorola Communications, Schaumberrg, IL.

Publisher/Editor
Howard Bierman

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Richard T. Davis

Associate Editor
Stacy V. Bearse

Contributing Editor
Harvey J. Hindin

Washington Editor
Paul Harris
Synder Associates
Suite 401
1012 14th, NW
Washington, DC 20005
(202) 628-2700.

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Editorial Office
50 Essex St.,
Rochelle Park, N.J. 07662
Phone (201) 843-0550
TWX 710-990-5071

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coming next month: Microwave Transistors

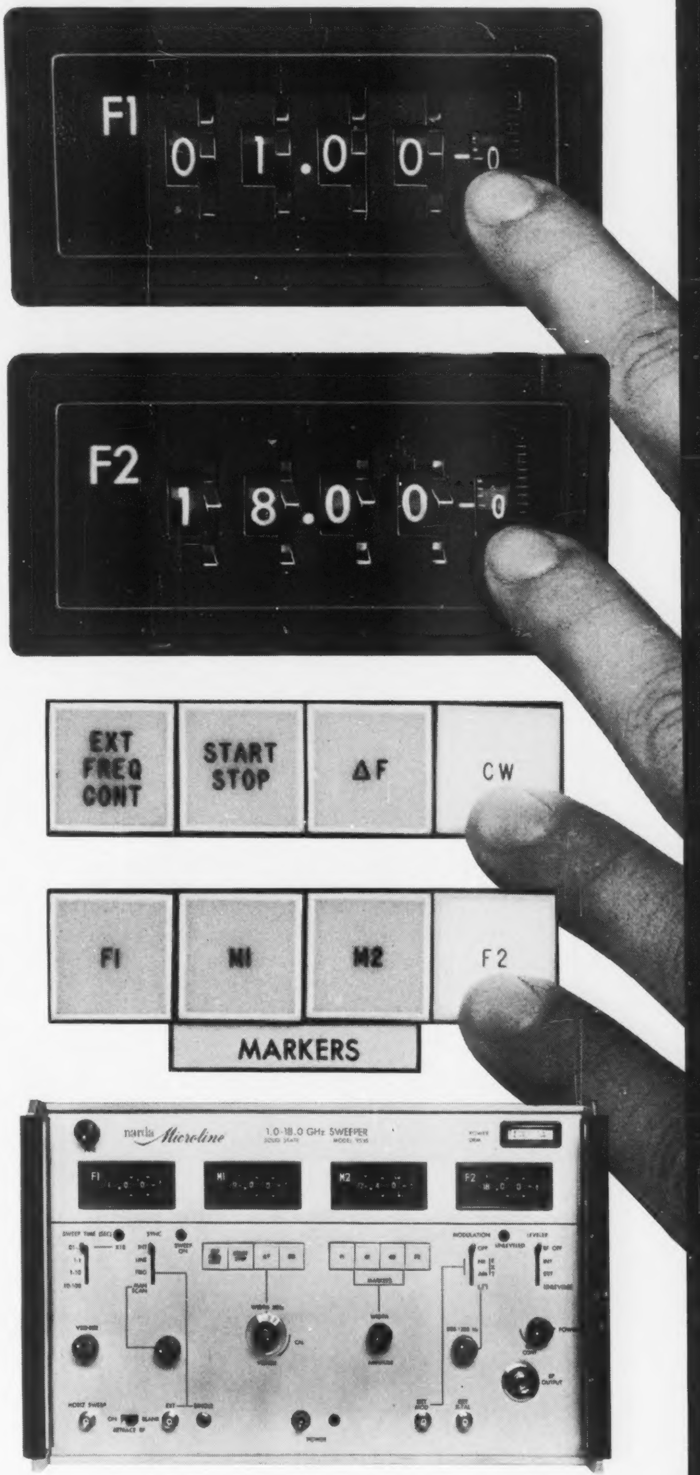
SIMPLE DC TESTS PREDICT MICROWAVE TRANSISTOR PERFORMANCE. J. Curtis and D. McCormac of PHI show how a transistor-curve tracer can effectively be used to predict rf performance and reliability of microwave transistors. This technique eliminates costly and time-consuming burn-in tests as well as elaborate rf test setups.

DESIGNING WITH GaAS FETS. G. E. Brehm and G. D. Vendelin of Fairchild Semiconductor discuss the effects of bias and packaging constraints in designing FET amplifiers. The construction and performance of the GaAs FET is covered; specifically, gain and noise figure and how each can be optimized. Stability criteria are also considered.

News: Do You Hear What I Hear?
Field tests indicate that humans can perceive low-power pulse modulated microwave energy in the 0.3 to 3 GHz range. The effect is electromagnetic in nature and not acoustic. This baffling phenomena is under study for the U. S. Office of Naval Research and the U. S. Army.

Sweep from 1 to 18 GHz this easy

select and read with six choices



Replace 6 Klystron Signal Generators with one Model 9535 — from 1 to 18 GHz.

Narda's newest generator/sweeper, Model 9535, is easy and quick to use —

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- **Distance viewing provided—no mistaking frequency**
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It eliminates the octave-band limitations and the associated cost and accuracy problems of ordinary sweepers and signal generators. It is now possible to test at all points over the range of 1 to 18 GHz. Because of the single set-up, it is ideally suited for military and commercial applications where frequency ranges overlap or where the single range of interest straddles multi-octave bands, or for the changing ranges of ECM systems.

Save man hours every day by eliminating plug-ins and warm-up time — eliminate BWO tube replacement budgets, plus getting crystal stability with phase-lock capability.

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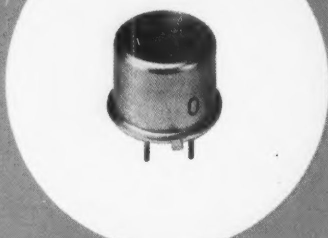
TO-5 Double-Balanced Mixers from DC...to...2 GHz



These new mixers offer the best performance and highest quality available in a 4-pin TO-5 package.

Individual units are hermetically sealed and specifications are guaranteed over a temperature range of −54°C to +100°C and after environmental stressing per MIL-STD-202D.

For additional data, call our Field Sales Office/Representative in your area or W-J/Relcom Applications Engineering at (415) 493-4141, ext. 637. Better yet, requisition your own evaluation unit from our stock.

Typical Performance at 25°C with +7 dBm LO

	Model M6V	**Model M6R**	**Model M6G**
Inputs (L):	.4 to 500 MHz	10 to 1200 MHz	.6 to 2 GHz
(R):	.4 to 500 MHz	10 to 1000 MHz	.6 to 2 GHz
Output (I):	DC to 500 MHz	DC to 1 GHz	DC to .3 GHz
Noise Figure:	5.5 dB	6 dB	6.5 dB
Isolation:	50 dB	40 dB	25 dB

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READER SERVICE NUMBER 8

news

Balloons raise repeaters for greater range with less power

1. **This high-flying aerostat** is engineered to carry satellite-quality repeater equipment up to altitudes of 15,000 feet. Designed to provide low-cost, multi-purpose communications for developing nations, the system is undergoing final testing in the Bahamas.

Stacy V. Bearse
Associate Editor

How can you cover 70,000 square miles with only one repeater station? Easy, just hang it on a balloon. The people at TCOM (Tethered Communication) Corporation, a subsidiary of Westinghouse Electric Corporation, are doing exactly that in a recently patented communication system designed for use in developing nations. Supported by a balloon, a satellite-quality repeater station can simultaneously transmit vhf or uhf television channels, am and fm radio or several thousand channels of mobile and stationary telephone communications, Teletype, telex, Telephoto and high-speed digital and analog data to receivers within a radius of 125-miles. The programming or data can originate at several ground locations surrounding the balloon's site and is relayed to the craft by 7 GHz microwave links.

A major advantage of this concept, as seen by the manufacturer, is that the system is not hindered by the typical 30 mile line-of-sight horizon that limits a conventional terrestrial broadcasting facility. Because this system does not have to rely on "bending" the signals beyond the horizon, transmitter power requirements are reduced and the effective broadcasting area is expanded. For example, TCOM points out that the signal strength received at a location 100 miles from a 1,000-foot conventional broadcasting tower with a radiating power of 100 kW could be equaled with only 3.2 W from a transmitter 10,000 feet aloft.

The vehicle for raising the transmitter to this altitude is a 7,000 liter helium-filled balloon called an aerostat. Capable of supporting an electronic cargo of 3,500 lbs, the aerostat measures 57 meters long and 27 meters high. Although this enormous craft seems intimidating while on the ground, it appears a mere speck in the sky when tethered at its working altitude of 10,000 to 15,000 feet. The communications package is suspended from the underside of the craft in a weather-proof enclosure. A stabilized mounting platform allows the balloon to respond to changes in wind condition without affecting the orientation of the directional communication equipment. An onboard generator driven by a lightweight Wankel engine powers the transmitting and receiving equipment. A week's supply of gasoline can be carried on-board. TCOM says that it takes about two-hours to haul down the balloon, refuel the generator and raise the ship back to its operating altitude. A tether cable capable of conducting power from a ground-based generator is under development.

To insure a high degree of reliability, a complete system consists of two aerostats tethered at 10,000 ft. and spaced 400 km apart.

Other advantages lauded by the manufacturer are lower installation and maintenance costs compared to conventional tower systems. TCOM's president, Richard S. Cesaro, states that "an aerostat communications system will initially cost about 20% of a conventional microwave and broadcast tower system and will have less than 10% of the operating costs." He adds, however, that the "aerostat system will complement instead of replace any existing communications system." A company spokesman estimated that although the cost of a system varies greatly with the complexity of its electronic package, a single aerostat system including aerial and ground electronics, would cost between \$4- and \$6-million.

Even though the cables and balloons are clearly lit, the manufacturer acknowledges the hazard that the system presents to aircraft traffic. A three-mile restricted flight zone is normally declared around an areostat station and radio beacons transmitted from the balloon are planned as navigational aids.

Specialized carriers—a boom for telecom equipment manufacturers

The construction of new nationwide communications networks by the specialized carried is proving a windfall for independent equipment manufacturers.

According to Frost & Sullivan, market researchers in New York City, the terrestrial specialized carriers during 1973 to 1975 will spend about $230-million on microwave equipment—nearly three times total industry sales in 1971.

Up to now, about 85% of US telecommunications equipment has been supplied by Western Electric, the manufacturing arm of the Bell System. Western Electric had annual sales of $6.5-billion last year.

In 1973, the specialized carriers took delivery of about 30% of the microwave component industry's output and ordered sufficient equipment to keep the industry busy for another couple of years. In some respects, the terrestrial specialized carriers have saved several independent microwave equipment makers from failure. Without the specialized carriers, the market for microwave-communications equipment would be still dependent upon sales in three traditional market areas—independent telephone companies, industrial corporations and the non-military government market (see Table 1). The outlook for the latter two markets is not too bright. Industrial corporations alone will have their annual purchases of microwave communications systems over the next seven years. A slight growth in government purchases is evident in Table 2; but largely as a result of special situations such as the possible construction of a $100-million combined microwave/vhf system to provide navigational control of vessels on inland waterways.

Industrial corporations and government agencies have not been keen on purchasing, operating and maintaining their own equipment. Only where forced through high telephone company charges or downright refusal to provide service do they undertake construction.

Harry Newton

Contributing Editor/Telecommunications Consultant to Frost and Sullivan

The existence of hungry specialized carriers, however, now frees them of the capital, maintenance and potential obsolescence burden.

The only bright spot in traditional markets is the independent telephone companies whose growth plans indicate respectable ambition. Although the independents provide service to more than 50% of the nation's geographical area, they have traditionally let Bell handle their long-distance requirements. Increasingly, the independents are pursuing every opportunity to provide their own long-distance requirements through the use of microwave-communications systems.

The big thrust of specialized carriers purchases began in 1973 and will continue through 1975 as the specialized carriers rush to complete their nationwide system, Table 3. As customers, the specialized carriers look to their suppliers for the following:

- The arrangement of financing. This has been the single most important issue facing potential suppliers. Financing has taken the form of term financing (MCI's first system was term financed by Raytheon), guarantee financing (where the supplier guarantees a portion of his sales against bank borrowings), supplier financing of research (as necessary in Datran's case), and supplier-equity financing (only Datran is apparently still negotiating).
- Proven capability in common-carrier equipment. As common carriers, the specialized carriers are adamant that the equipment they purchase has proven quality and reliability. This type of equipment contrasts strongly with the telecommunications purchases by the military and the aerospace industry whose purchases (particularly in large fixed microwave systems) tend to be "one of a kind, state-of-the-art."
- Corporate commitment to the latest technology. Despite most specialized carriers' unwillingness to experiment with unproven technology (excepting Datran), all are obsessed that their technology must be the latest and their supplier must incorporate the latest C-MOS, LSI into their equipment.
- Proven willingness to support equipment. This applies particularly to after sales service, maintenance support, the production and inventorying of adequate spare parts, especially of prior years' models.
- Long term financial commitment to the industry. This means two things: (a) the willingness to stay with the industry through its thicks and thins and (b) the ability to survive financially through it all.

How well the equipment manufacturer will fair depends, of

(continued on p. 12)

Table 1 UPCOMING COMMERCIAL PURCHASERS OF MICROWAVE EQUIPMENT
1973-1980 Inclusive

	Number of Stations			
	Conservative Assumption	*Market Share*	*Growth Assumption*	*Market Share*
Specialized Carriers	1,220	16%	1,750	22%
Telcos, incl. non-Western Electric purchases by Bell Cos	2,400	32%	2,400	30%
Non-military Fed & State Govts.	2,700	36%	2,700	33%
Industrial	1,200	16%	1,200	15%
TOTAL	7,520	100%	8,050	100%

Source for all tables: Frost and Sullivan, N.Y.C.

TABLE 2 COMMERCIAL MICROWAVE COMMUNICATION SYSTEMS DELIVERIES*
Millions

	1973	1976	1980	1973-1980 incl. Total
Specialized Carriers	$67.8	$75	$68.5	$505
*Telcos**	$75	$95	$145	$854
Industrial	$40	$35	$20	$249
Government (non-military)	$50	$70	$90	$585
Grand Total	$233	$238	$324	$2193

*Excluding Western Electric deliveries of WE equipment to Bell telcos. Includes initial and expansion multiplex and radio and other associated equipments.

news

Diffraction grating extends BW of CO_2 waveguide laser

Richard T. Davis
Managing Editor

By incorporating a diffraction grating into a high-pressure CO_2 waveguide laser, scientists at Hughes Research Labs., Malibu, CA, have extended its tuning bandwidth to over 1 GHz. This is an important breakthrough particularly for proposed space borne 10.6 μ laser communications links because a laser heterodyne-receiving systems must track the incoming laser frequency. In low orbit satellite-to-synchronous satellite communications links, the resultant doppler shift is about ± 700 MHz; and the laser used at the LO must cover this entire doppler range.

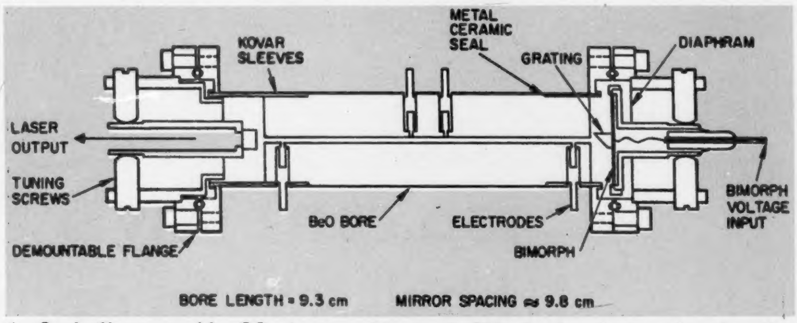
Waveguide lasers operate at gas pressures well in excess of those typical of conventional CO_2 lasers (which are limited to a 50 MHz tuning range). Pressure broadening of the laser transition results in wider bandwidth and increased frequency tuning capability.* Operating pressures well above 300 Torr have been demonstrated where the pressure broadened linewidth is greater than 1.8 GHz. Frequency tuning is achieved by varying the length of the waveguide resonator using piezo-electric tuning elements.

"To make use of this bandwidth capability, however, it was important for us to incorporate a diffraction grating in the resonator. "This enables us to tune the laser without it changing transitions or jumping modes," says Dr. Dick

(continued on p. 14)

Footnote

*See "Tiny CO_2 Waveguide Laser Developed," MicroWaves, November, 1972, (p. 9 and 14).



1. **Seal-off waveguide CO_2 laser** achieves 1 GHz tuning by varying length of the laser resonator. The 1/4 in. square diffraction grating (97% efficiency) is mounted on the bimorph which moves 5μ when 22V is applied.

Specialized carriers—boom for equip. mfg.

(continued from p. 10)

course, on the acceptance of the specialized services. They will probably begin their services by encroaching into an existing (and probably monopoly) market, developing a business base and then developing a new market altogether. Nonetheless, the following trends are apparent:

- Based on a survey conducted by Frost & Sullivan with large communications users (Fortune 500 types), 85% said they expected that eventually one or more of the specialized carriers would serve them.
- In November, 1973, MCI reported sales orders worth over \$9-million in annual revenues. MCI was the first terrestrial carrier to report firm orders.
- Bell said it would lose over \$250-million in annual revenues in 1976 to the specialized carriers (Bell's statement owes its inspiration more to politics and less to market research).
- The market for private-line services in 1973 was \$1.5-billion and by 1976 should be at least 50% higher.

Apart from market acceptance, another unknown is the willingness of the regulatory agencies to take a strong stand against Bell's apparent dislike for competition. Latest Bell tactics are threefold: refusal to interconnect with the specialized carriers except in the most limited situations; requests for a "moratorium" on competition while comprehensive, time-consuming economic studies are undertaken and finally, requests for substantial price cuts on competitive services.

These tactics will be time delaying. They will drain the resources of some of the smaller specialized carriers, which in turn, will be absorbed into the larger operators. This process of consolidation has already begun. Towards the end of 1973, MCI bought N-Triple-C and Southern Pacific Communications bought United Video. ••

Table 3
THE TERRESTRIAL SPECIALIZED CARRIERS

	Background	*No of microwave sites proposed*	*Total route miles planned*	*Cost of network, millions*	*Planned Ultimate Scope of Network*
CPI	CATV, TV haulage	50	1000	\$9.0	Texas & La.
Datran	University Computing Co.	166	3200	\$150+	Coast-to-Coast
Eastern Microwave	CATV, TV haulage	26	450	\$13	Boston-Washington
MCI (incl. NCCC)	Pioneer	700	13,500	\$100	Nationwide
Southern Pacific (incl. United Video)	Railroad communications	300	6500	\$30	Coast-to-Coast
U.S. Transmission Systems (ITT)	World telecommunications	100	3000	\$30	Houston to NYC
Western Tele-Comms	CATV, TV haulage	244	8860	\$65	Coast-to-Coast

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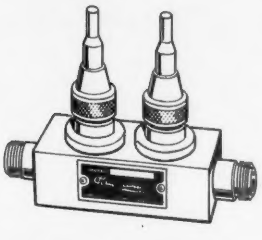

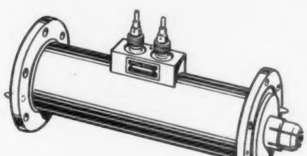

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READER SERVICE NUMBER 13

Transfer chemical laser delivers 13% efficiency

Richard T. Davis
Managing Editor

A ten liter transfer chemical laser, based on the reaction of D_2, F_2 and CO_2, has been developed which provides an overall efficiency of 13%. Xenon flash lamps initiate the reaction to produce excited DF, the energy of which is then transferred to the CO_2 to produce 205 Joules of laser energy at 10.6 μ. According to Jerry Parker, Head of the Chemical Laser Section at Hughes Research Labs., Malibu, CA, smaller versions of this type laser have been in development for some time now with up to 1.2% efficiency. However, this is the first such device to operate at an efficiency competitive with electrically pumped CO_2 lasers. The ten liter volume and 200 Joule output energy are about 40 times larger than previous devices.

"The key to this increased efficiency is the design of the laser reaction chamber," says Parker. Speaking at last month's Electron Devices Meeting (Washington, DC, December 3, 4 and 5), Parker said that "increasing the transverse dimensions of the laser chamber and coating all wall surfaces with a highly reflective material, the ultra-violet photon loss to the reaction medium is enchanced relative to wall losses."

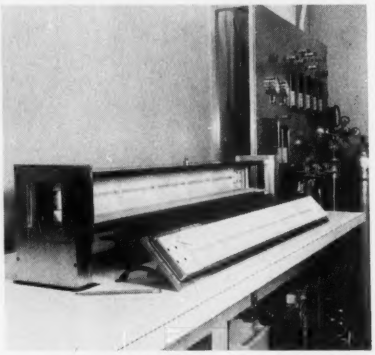
Up to now, the chief disadvantage to the flash lamp initiation technique for the chemical laser has been the low overall electrical efficiencies—about 1%. By scaling to larger volume devices, the electrical efficiency of flash photolysis initiation is increased by more than an order of magnitude while maintaining high specific volumetric extraction and chemical efficiencies.

The 10 liter laser chamber, shown in the figure, has two linear xenon flash lamps recessed from the 10 cm x 10 cm cross-sectional laser cavity area. At the ends of the reaction volume are remotely operated shutters which protect the resonator mirrors from the corrosive atmosphere. The gas mixture consists of F_2: D_2: O_2: CO_2: He in proportions of 2:1:0.1:5:10 at 300 Torr pressure.

The flashlamps are constructed of fused quartz tubing (1 m x 1 cm) and are filled with 150 Torr xenon. Two 7.5 μ F capacitors are charged to 10 to 15 kV and discharged simultaneously through the flashlamps which provide an intense optical pulse of 15 μ sec duration for photodissociation of F_2.

In the tests conducted, various gas mixtures and pressures ranging from 200 to 400 Torr were tried. The excitation levels were also varied by changing the capacitor charging voltages, and laser energy was found to increase linearly with flash-lamp energy. With increased flourine concentrations, it was found that pulse durations shortened significantly. "The most puzzling aspect of the device," claims Parker, "has been the failure to obtain linear energy scaling with fill pressure in contrast to results achieved with small volume systems. This is currently under study."

Parker predicts that ultimately this laser system can achieve a 25% efficiency. The chemical laser has application as a high power radar, or in applications where high voltage conditions are not desireable. ••



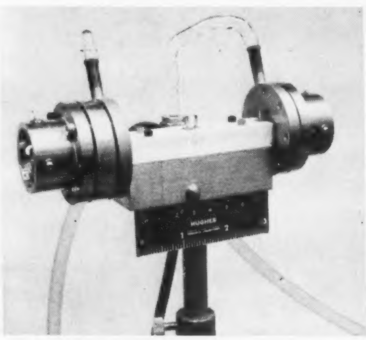
1. **Partially assembled DF/CO_2 chemical laser** shows the two linear xenon flash lamps. Mirrors and a highly polished KCl output window complete the assembly but are not shown.

Diffraction grating extends CO_2 laser BW

(continued from p. 12)

Abrams, Head of the Electro-optics Section at Hughes Research Laboratories. A diffraction grating acts as a frequency selective laser mirror, and only reflects a single CO_2 transition into the waveguide. Thus for any other transitions the laser resonator is not properly aligned.

In the tunable waveguide laser developed by Abrahms, Fig. 1, the 150 lines/millimeter diffraction grating is mounted on a bonder bimorph—a type of piezo-electric transducer. "An applied voltage of 22V is sufficient to translate the bimorph 5.3 μm or one free spectral range," says Abrams. The gas discharge region is contained in a 9.5 cm x 1.0 mm beryllium oxide tube which is conductively cooled to a heat sink. It is terminated at the opposite end by a 97% reflecting output mirror. The tube is statically filled with 220 Torr of a He, CO_2, N_2, Xe gas mixture. "The peak output of this laser, Fig. 2, is about 0.6W," says Abrahms, "and it tuned over 1 GHz by controlling the bimorph voltage. No line jumping occurred over this entire range. We are expecting shortly to be able to achieve 1.5 GHz tuning." ••



2. **This CO_2 waveguide laser** tunes over 1 GHz at 10.6 μ and delivers 0.6 W.

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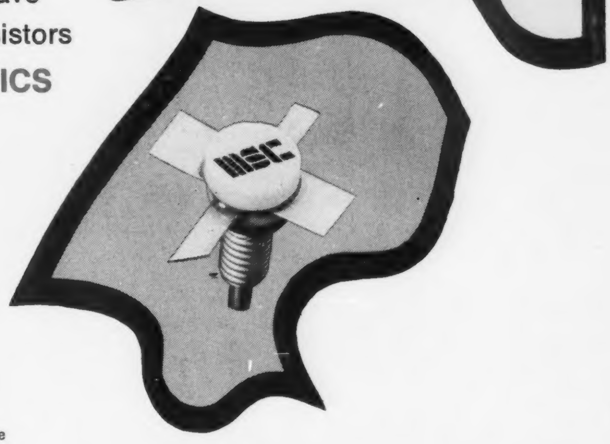

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Power Gain (P_G)	10 dB	9.0 dB	9.0 dB	8.0 dB	9.0 dB
Efficiency (η_C)	35-40%	35-40%	45-50%	45-50%	60-70%
Voltage (V_{CC})	43V	43V	43V	43V	40V
Impedance (Z_{IN})	0.5+j5.0	0.38+j4.7	4.0+j7.5	2.0+j5.0	7+j7
Impedance (Z_{CL})	5.3−j6.3	2.0−j4.2	4.0-j3.5	2.0−j3.0	12-j5
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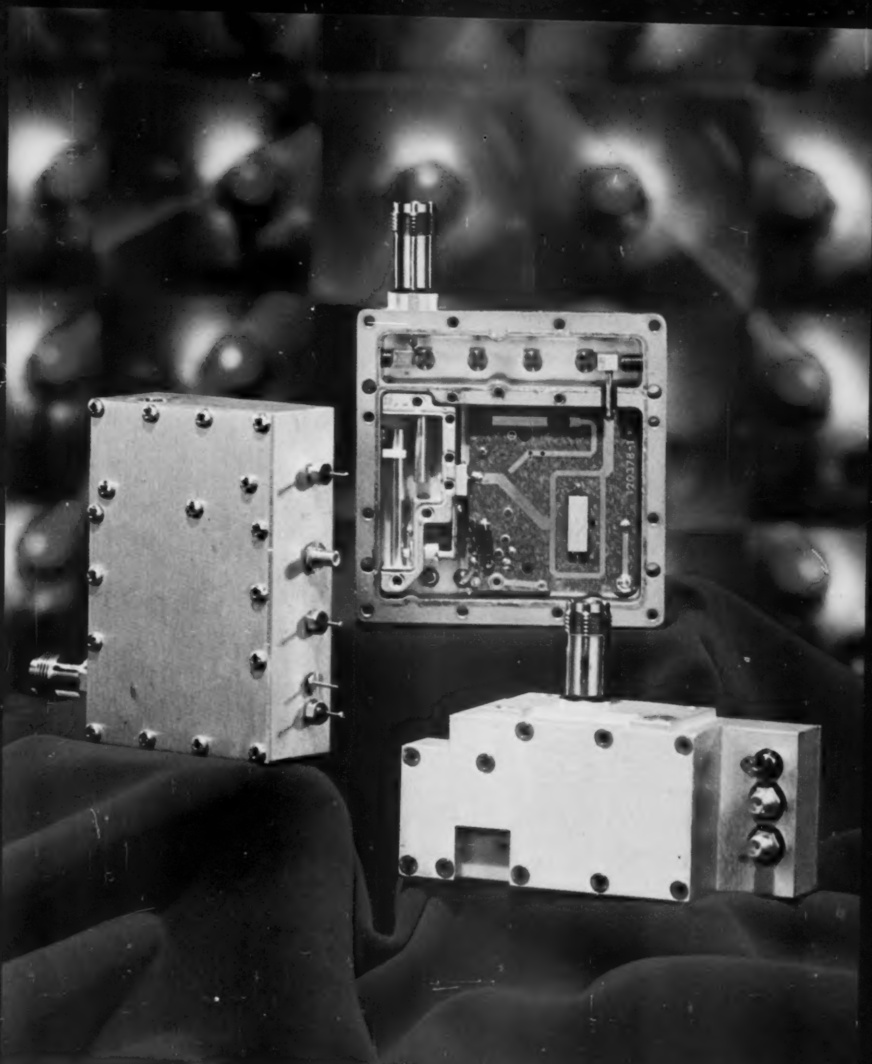

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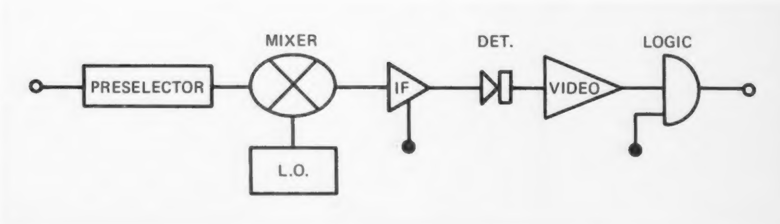

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news/industry

Plant News

Southern Pacific Communications Co., San Francisco, CA will acquire all of the stock of **United Video, Inc.**, Tulsa, OK. United Video is **LVO Cable's** specialized common carrier microwave subsidiary. The purchase price will exceed $4 million.

Rockwell International, Los Angeles, CA has approved an agreement in principle to merge with **Admiral Corp.**, a manufacturer of consumer electronic products and major home appliances. **Collins Radio Co.**, Cedar Rapids, TX will merge into **Rockwell International.**

MCI Communications Corp., New York and **N-Triple-C, Inc.**, announced they have reached an agreement for a merger involving the two companies. Both companies are business communications common carriers serving the special needs of intercity, private line communications users.

Maury Microwave Corp., Cucamonga, CA has appointed **B.D. Hummel Co.**, Utica, NY as its Engineering Sales Representative for Northern New York State. They will be exclusive sales agents in the northern portion of the state.

Dalmo Victor, Belmont, CA a division of **Textron's Aerospace Group**, Providence, RI has become an operating unit of **Bell Aerospace Company**, also a division of Textron. Dalmo Victor produces electro-magnetic defense systems, aerospace antennas and electro-optical equipment.

Watkins-Johnson Co., Palo Alto, CA announced that it will dissolve its relationship with the remaining manufacturers representatives around the country by April 1974. A new field office will be established in Boston and additional manpower will be added to the Dayton and New York offices. The first reduction of field representatives was announced a year ago.

Addington Laboratories, Inc., Sunnyvale, CA announced the appointment of **Ashby Associates, Inc.**, Dayton, Ohio as its representative in Ohio, Michigan; **Cain & Company**, Mt. Prospect, IL for Illinois, Indiana; **Eastern Instruments**, Silver Springs, MD for Maryland and West Virginia, and **Russell Engineering Services, Inc.**, Waltham, MA in the New England States.

Alan Industries, Inc., Columbus, IN announced that the law suit filed against them has been dismissed. The suit, filed by Texscan Corp., Indianapolis, IN was dismissed on the basis of prejudice. The alleged complaint was of a conspiracy by Alan Industries to recruit employees from Texscan.

Contracts

Scientific-Atlanta, Atlanta, GA, a contract to provide the distribution electronics and headend equipment for the **Lexington and Thomasville, North Carolina CATV system**, announced by the **Triangle Broadcasting Corp.** of Winston-Salem, NC. Also, a contract to Scientific-Atlanta for the turnkey installation of a CATV system to serve Blackfoot, ID. Construction has begun with the system expected to be turned on in early 1974.

RCA, NY a $600,000 contract for twelve advanced weather radar systems by **British Airways.** Five are to be installed in Concorde SST's scheduled for delivery in 1975.

Litton Industries' LIFEF (Litton Technische Werke) division, Freiburg, Germany, a contract for approximately $200,000 from the **Boeing Company** to provide its LITEF PL-41 gyrocompass/navigation system for **NATO Patrol Hydrofoil Missile ships (PHM)** which Boeing is building for the US Navy.

GTE Sylvania Inc., Needham, MA, a $5.7 million contract for continued operation and maintenance of a missile-tracking system in the South Pacific by the **US Army Safeguard Systems Command**, Huntsville, AL.

Varian Associates, Palo Alto, CA, a $500,000 contract from **Wright Patterson Air Force Base**, Dayton, OH. The contract calls for developing large scale techniques manufacturing for producing a line of "mini" traveling wave tubes. Objectives include reducing tube cost through special tooling and new techniques without affecting the quality of the TWT's.

PRD Electronics, Inc., Westbury, NY, a subsidiary of **Harris-Intertype Corp.**, has appointed **Kenneth W. Meyers Co.** as their new sales representative. They will provide sales and service to PRD customers in Western Kentucky, Indiana, Illinois, Wisconsin, Iowa and Minnesota.

People

James C. McDade has been named chief engineer of the **Semiconductor Division of Alpha Industries, Inc.**, Woburn, MA.

Robert L. Sleven was appointed deputy director of the **Applied Electronics Division of Cutler-Hammer's AIL Division**, Deer Park, Long Island, NY.

Jeffrey O. Henley has been promoted to the newly created position of manager, business development for **Fairchild Camera & Instrument Corp.**, Mountain View, CA. He will be responsible for evaluation of existing new business development programs and for the formulation of new business strategies.

Bruce L. Baker has been appointed a national sales manager at the **Airtron Division of Litton Industries, Inc.**, Morris Plains, NJ. He will be responsible for all of the microwave sales.

Raymond H. Uhrich has been appointed to the newly created position of vice president-marketing at **PRD Electronics, Inc.**, Syosset, Long Island, NY.

Donald A. Wolf has been named manager of production operations for the **Western Division of the Electronic Systems Group of GTE Sylvania Inc.**, Mountain View, CA.

Leonard B. Mackey has been promoted to general patent counsel of **International Telephone and Telegraph Corp.**, NY.

Henry B. Marron has joined **Scientific-Atlanta, Inc.**, Atlanta, GA as director of engineering for the Cable Communications Division. He will be responsible for all the engineering and product development for the line of headend equipment, distribution electronics, home terminal devices, and antenna systems.

Len Lazarus has joined **LNR Communications, Inc.**, Farmingdale, NY as assistant manager of marketing.

W. Dale Leonard has been appointed manager of independent telephone accounts, microwave marketing, **Collins Radio Co.**, Dallas, TX.

Robert P. Bryan has been appointed manager of the microwave semiconductor dept. at **Hughes Research Labs**, Torrance, CA.

Dr. Samuel Sensiper has joined **Transco Products, Inc.**, Venice, CA as director of engineering.—*S.L.B.*

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READER SERVICE NUMBER 20

news/washington

Paul Harris—Washington Editor

COMSAT hot over ITT Worldcom hotline contract

The government's contract award to ITT World communication to provide a communications "hotline" via satellite between the U.S. and Russia has prompted cries of "foul" from Communications Satellite Corp.

In a recent message to the Defense Commercial Communications Office, COMSAT made it known it was clearly unhappy about being shut out of the deal. ITT Worldcom's charge of $153 per month for installation, operation, and maintenance of the government furnished equipment at the earth station is "clearly noncompensatory," the firm said. What's more, said COMSAT, a minimum of four people would have to provide 24-hour service at the Edam, W. V. facility.

Upshot: COMSAT asked DECCO to suspend the award to ITT Worldcom "pending clarification of these matters." The hotline is a two-satellite system, one of which is slated to be operated by ITT Worldcom over the Intelsat Satellite Communications System, and the other by Russia over the Molniya System. Plans call for both systems to operate simultaneously with the same traffic to insure service if one fails.

Senate bill would abolish OTP

Sens. Lowell Weicker (R-Conn.) and Abraham Ribicoff (D-Conn.) have introduced legislation to abolish the White House Office of Telecommunications Policy and transfer its functions to the Federal Communications Commission.

However the proposal, which was sent to the Commerce Committee, met with a cool reaction from Sen. John Pastore (D-R.I.), whose Communications Subcommittee spawned OTP in the first place. The measure is actually a belated (by almost a year) reaction to OTP Chief Clay T. Whitehead's infamous "ideological plugola" speech that called for breaking up TV networks. That talk has caused many headaches at OTP, including a whopping budget cut from Congress last fall.

Yet, another area of contention for Weicker and Ribicoff is OTP's use of the Commerce Department for research assignments. "Thus, armed with technical and economic analysis, OTP can justify its policy decisions in a forceful manner in its dealings with other government agencies," complained Weicker. "I question the type of relationships that have developed between OTP and its research adjunct."

FCC gives Packet new carrier role

Packet Communications has been cleared by the Federal Communications Commission to become the first "valued-added carrier" that will use computers to organize data into blocks and then transmit it at high speeds over microwave circuits or telephone lines. Similar requests from other firms should also seek quick approval.

At the same time, the FCC allowed AT&T to relax its traditionally restrictive rules on the resale of transmission services to allow the operation of value-added carriers.

Other applications for the new data-communications system have been filed by subsidiaries of Bolt Beranek and Newman Inc., MCI Telecommunications Corp. and National Computer Switching Utilities Inc. Meanwhile, Packet said it will link 26 pairs of cities by early 1975.

The new authorzation has also opened a Pandora's box of regulatory issues that the FCC plans to tackle as soon as possible. But officials expect proceedings on the long range issues will be tedious and controversial.

(continued on next page)

news/washington

(continued)

FCC will peek at unrouted message traffic

The FCC has begun a full-scale investigation into the 30 year-old formula for the distribution of unrouted international message traffic outbound from the U.S. The outdated formula has been the subject of a landslide of criticism lately, particularly from ITT Worldcom. The firm took issue with the formula's tendency to preserve the relative market share of each international carrier at the 1942 or earlier level. It also criticized the existence of schedule B, under which RCA Global Communications was compensated for its lack of access, among the major IRCs at that time, to an affiliated domestic system.

The commission's plan is to independently probe the entire matter to decide for itself the formula's present defects, the effects of the IRC's, and the quality of service and rates charged. It will also explore the reasons for existing overages and deficiencies in assigned quotas.

OTP's updating Communications Satellite Act

After conceiving the idea late last year, the Office of Telecommunications Policy has finally begun soliciting views of other government agencies on proposed amendments to the 1962 Communication Satellite Act. Legislation has already been drafted to provide changes in the country's international communications policy, but Congress—involved in more controversial OTP matters—has so far sat on the proposals.

Aim of the legislation is to eliminate unnecessary restrictions affecting COMSAT, and to authorize executive branch oversight concerning future communications satellite systems that involve the U.S. and foreign countries. Most important, says outgoing OTP chief Clay T. Whitehead, is that an "open door policy' be established so that others can compete with COMSAT for the ventures. OTP figures that additional systems can be created separate from Intelsat, and that "such systems would necessitate a high level of government-to-government cooperation and accord." Therefore, it reasons, the private international carrier industry and the federal government should coordinate their activities.

Bernard Strassburg exits FCC

The FCC's Common Carrier Bureau chief Bernard Strassburg retired last month after 10 years at the helm of the microwave industry's most important government regulatory department. A recognized authority in communications for 31 years, Strassburg played a leading role in the formation of the 1962 Communications Satellite Act. He's been in charge of all regulatory aspects of global communications satellite program, domestic satellite communications, interconnections and entry of new carriers.

New microwave service proposed by FCC

The Federal Communications Commission has proposed to establish a private operational fixed microwave radio service to consolidate its far-flung regulations over the industry. The new rule will cover present licensing and operation of private operational fixed systems on microwave frequencies above 952 MHz that are now under interim rules under various safety services.

Noting that the number of private microwave stations has tripled since 1960 to nearly 10,000, the FCC said the rules need to be updated to meet the demands of current and future industry development. Big problem: many of these stations tend to concentrate in microwave corridors producing pockets of congestion. At the same time, of course, the need for more frequencies is increasing.

news/international

Improved stability offered with dual-gate FET

A GaAs dual-gate FET has been developed using Schottky Barriers for the gates that exhibit a 3 dB noise figure and power gain of 12 dB at 4 GHz. According to Shojiro Asai of Hitachi Central Research Labs, Tokyo, Japan, gain variations over a 30 dB range may be obtained by varying the second gate bias without significantly affecting the input impedance. In the dual-gate structure, the second gate is between the first gate and the drain—the first Schottky gate being 1.2 μ long and the second gate is 2.5 μ long.

"The stability factor and maximum stable gain are much larger than single gate units," says Asai, "thereby offering greater amplifier design flexibility." These advantages are realized only by minimizing the parasitic feed through capacitance of the package.

British P. O. approves new mw tower to beam to France

A new microwave relay tower, which will transmit and receive power at Tolsford Hall in Rover over a 30-mile hop to Fiennes, France, is planned to be built and completed by 1975. The existing tower at Tolsford Hill is being strengthened to support additional dishes but will be dismantled by 1975. The new tower designed by the Property Services Agency of the Dept. of the Environment will rise 210 ft. and have a 70 ft. tubular steel tower on top.

New transistor plant opens in France

The first of four new plants have been built near Bordeaux in South Western France by TRW Systems, Inc., for production of rf and communications transistors, potentiometers and fractional HP motors. "Ultimately," says TRW's European Manager, Dr. John Bohrer, "each product line will be built in a dedicated plant," on the 100,000 sq. ft. site. Three additional plants are planned.

"Diffusion methods will be employed at the Bordeaux plant when the European demand makes it economically feasible," says Bohrer, "sometime toword the end of 1974. Current sales in Europe are running at about $4-million per year. Bohrer claims to have a 50% share of the available European transistor market. The transistors presently made operate up to several GHz and deliver between 1 to 10 W.

Brazil to get second satellite ground terminal

The Brazilian Telecommunications Administration has signed a $3.35-million contract with ITT Space Communications to build a new earth station alongside its first terminal in Tangua—about 35 miles from Rio de Janeiro. Delivery of the terminal will be in about one year. The station will operate via Intelsat satellites and will link traffic with the U. S., Germany, France, Italy, Argentina, Great Britain, Canada and Mexico.

200 kW S-band klystron has TWT BW capability

A novel eleven cavity S-band klystron that can deliver 200 kW peak power over a 10% 1 dB bandwidth has been developed at Thomson-CSF, Paris, France. This klystron has a gain of 50 dB and an overall efficiency of 30% over a 2850 to 3150 MHz frequency range.

"TWTs presently available can have bandwidths of an octave or more at levels of tens of watts," says Georges Faillan of the Electronic Tube Group, "but at the 100 or 200 kW level their bandwidth is usually no wider than 15%." By increasing the number of resonant cavities in the klystron and increasing the spacing between them, a 10% instantaneous bandwidth is achieved. Extensive use of computer-aided design was used in the development of the tube.

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READER SERVICE NUMBER 27

r&d roundup

Harvey J. Hindin, Contributing Editor

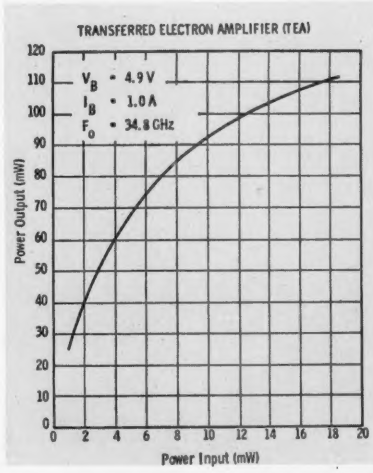
Transfer your electrons

Moderate power, high-gain, millimeter wave amplification has now been achieved using GaAs transferred electron devices. Both a waveguide and a coaxial structure have been designed and constructed with saturated power comparable to that obtainable from an oscillator. This accomplishment which opens the door to further developments in solid-state millimeter-wave amplifier technology was reported in *PROC. IEEE,* Vol. 61, No. 10, Oct., 1973, pps. 1502-1504. The authors, R. E. Goldwasser and F. E. Rosztoczy describe their experimental results in detail although construction details and photographs are lacking.

The first amplifier is built in half-height waveguide and is iris-coupled to the load. The TED is center-mounted on a post near the back wall of a half-wave cavity. Dc bias is fed through an appropriate multi-section filter. Small signal gain is 13 dB at 34 GHz. Output power is up to 17 dBm with a 16.2 dB noise figure and a 180 MHz 3 dB bandwidth. Large signal characteristics are similar.

Use of a coaxial-hybrid structure allows 2 GHz bandwidths to be obtained at 1% dc to rf efficiencies. Other specifications were comparable to those achieved with the waveguide structure.

Goldwasser and Rosztoczy believe that the 16 dB noise figure can be improved with an optimized doping profile for the TED. They also feel that full waveguide bandwidth should be obtainable with the use of improved circuitry.

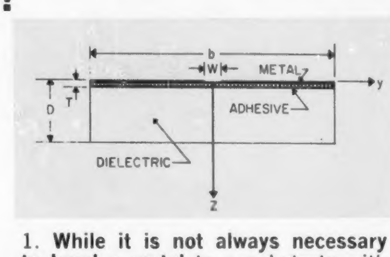


1. **Circulator losses are included** in the determination of power output. Note the lack of gain expansion at low-drive levels. The compression characteristic is desireably smooth.

What does the glue do?

It's to be expected that an adhesive layer between the metal and the substrate in a slot-line structure will effect the slot-line wavelength, and this effect has previously been noted experimentally. Thanks to J. B. Knoor and J. Saenz and "The Effect Of Surface Metal Adhesive On Slot-Line Wavelength" (*IEEE Trans on MTT*, Vol. 21, No. 10, pps. 642-644, Oct., 1973), we now have a theory and confirming experimental data.

The perturbation analysis performed by the authors show that the presence of adhesive causes an increase in wavelength when the dielectric constant of the adhesive is less than that of the substrate. The wavelength increase is in direct proportion to T/D, but frequency dependence is small.



1. **While it is not always necessary to bond a metal** to a substrate with an adhesive, the adhesive does affect wave length. This is frequently encountered in a slot-line structure.

Careful measurements were performed for many substrates and surfaces. Different adhesives and thicknesses were also tried. It was found that in all cases, the experimental data could be accounted for by application of the newly-derived theory.

W-J quad-ridged horn antennas cover 1 to 18 GHz in octave bands with selectable polarization.

Watkins-Johnson's 8326 Series high efficiency quad-ridged horns provide high gain, directional patterns over octave bandwidths with the capability for horizontal, vertical and (with 90° hybrid) circular polarization.

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The W-J design expertise responsible for the WJ-8326 Series is available for the custom design of quad-ridged horns for other frequency ranges and performance specifications.

For further information on the WJ-8326 Series or any other Watkins-Johnson antenna or antenna system, contact your local W-J Field Sales Office or Antenna Applications Engineering in Palo Alto at (415) 493-4141.

Specifications (any antenna):

Gain:	7 dB (low end)
	12 dB (high end)
3 dB B/W:	60° to 35° (E plane)
	65° to 40° (H plane)
VSWR:	3.0 : 1, max.

Cross Polarization: 20 dB, min.
Front to Back: 20 dB

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READER SERVICE NUMBER 29

news/meetings

January

29-31. Reliability & Maintainability Symposium. Biltmore Hotel, Los Angeles, CA. Contact: C. M. Bird, IBM Corp., 7900 N. Astronaut Blvd., Cape Canaveral, FL 32920.

February

13-15, 1974. The 1974 IEEE International Solid-State Circuits Conference. Philadelphia Marriott Motor Hotel, Philadelphia, PA. Under the co-sponsorship of the IEEE Solid-State Circuits Council, IEEE Philadelphia Section and the University of Pennsylvania. Contact: G. A. Alphonse, RCA Corp., Princeton, NJ 08540.

19-22. 3rd Annual National Communications Week Convention and Exposition. Chase-Park Plaza Hotel, St. Louis, MO. Sponsored by the Communications Systems Management Association. Fee: $125-members before 12/31 and $150 non-members before 12/31. Contact: CSMA Headquarters, 1102 West Street, Suite 1003, Wilmington, DE 19801 (302) 658-4117.

March

12-14. Aerospace & Elec. Sys. Winter Convention (WINCON). Mariott Hotel, Los Angeles, CA. Contact: D. A. Hicks, Res. & Tech., 1800 Century Park East, Century City, CA 90067.

12-15. Zurich Digital Communications International Seminar. Swiss Federation Institute of Technology, Zurich, Switzerland. Contact: W. Guggenguehl, Institut fur Fernmeldetechnik ETH, Sternwartstrasse 7 CH-8006 Zurich, Switzerland.

19-21. Electro-Optics International Exhibition. Metro-Pole Exhibition Center, Kiver Comm. Ltd., 149-155 Ewell Road, Surbetin, Surrey, England. 01-3900-2810282.

26-29. IEEE INTERCON-1974 International Convention and Exposition. Production Exhibition, New York Coliseum Convention technical program, Statler Hilton Hotel, New York City, NY. Contact: Don Larson, Manager, IEEE INTERCON, 3600 Wilshire Blvd., Los Angeles, CA 90010.

April

1-6. Seventeenth International Electronic Components Exhibition. Paris, France. Contact: Jean Pierre Duclos, SDSA Press Service, 14 Rue De Presles, 75740 Paris, France.

2-4. Reliability Physics Symposium. MGM Grand Hotel, Las Vegas, Nevada. Contact: Program Chairman: I. A. Lesk, Motorola, Inc., 5005 East McDowell Road, Phoenix, Arizona 85008.

news/meetings

8-11. Computer Aided Design International Conference & Exhibition. University of Southampton, Southampton, England. Contact: Inst. of Civil Engineers, Great George St., Westminster, London SW 1, UK.

9-11. 1974 International Optical Computing Conference. Zurich, Switzerland. Contact: Harry Hayman, PO Box 639, Silver Spring, MD 20901.

16-18. Optical & Acoustical Micro-Electronics. Commodore Hotel, New York. Contact: Jerome Fox, PIB, 333 Jay St., Brooklyn, NY 11201.

21-24. 1974 IEEE International Symposium on Circuits and Systems Theory. Sir Francis Drake Hotel, San Francisco, CA. Contact: L. Besser, Farinon Electric, 935 Washington St., San Carlos, CA 94070.

22-24. Communications Satellite System Conference. International Hotel, Los Angeles, CA. Contact: Dave Lipke, Comm. Satellite Corp., 950 L'Enfant Pl., S.S.W., Washington, DC 20024.

29-May 1. Southeastcon. Dutch Inn Orlando, FL. Contact: B. E. Mathews, Florida Tech., Box 25000, Orlando, FL 32816.

May

14-17. Intermag Conference. Four Seasons Sheraton, Toronto, Canada. Contact: R. C. Byloff, Wolf Research & Development Corp., 6801 Kenilworth Ave., Riverdale, MD 20840.

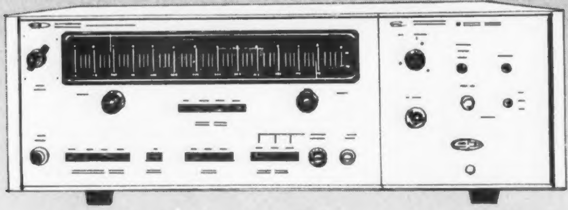
13-15. National Aerospace & Electronics Conference (NAECON). Dayton Convention & Exhibition Center, Dayton, OH. Contact: NAECON 74, 140 East Monument Avenue, Dayton, OH 45402.

Call for Papers

Deadline: March 15, 1974. 1974 IEEE International Symposium on Information Theory. University of Notre Dame, Notre Dame, IN. Areas of interest: coding theory, communication systems, computational complexity, detection and estimation, pattern recognition, etc. Submit a 500-word summary to R. T. Chien, Coordinated Science Labs, University of Illinois, Urbana, IL 61801. Symposium will be held on Oct. 27-31.

Deadline: April 1, 1974. Integrated Optics and Optical Waveguides. Papers are to be used in the special issue of the IEEE Transactions on Microwave Theory and Techniques, January, 1975. Areas of interest: thin-film waveguides, optical fibers, waveguide interconnections, integrated systems and subsystems. Submit in triplicate to: D. Marcuse, Bell Labs, Crawford Hill Lab, Box 400 Holmdel, NJ 07733.

SWEEP 10 MHz TO 18,500 MHz WITH ONLY 2 PLUG-INS!



You read it right. *One* Kruse Model 540 Multiband Sweeper and *two* RF oscillator plug-ins blanket the microwave spectrum. One plug-in allows internally leveled continuous sweep from 10 MHz to 4.2 GHz; the other, 3.7 GHz to 18.5 GHz. ***No other solid state general purpose sweeper*** system offers this capability. Price $950, plus plug-ins ($3,250 to $8,650).

Other ranges? Of course. *23* RF plug-ins, plus options, for the Model 540 Sweeper are available now, with more to come. Leveled and unleveled plug-ins cover from one to three bands each – all the way from 100 kHz to 18.5 GHz.

For immediate demos, call your nearby Scientific Devices sales office or Kruse Electronics Division, Systron-Donner Corporation, 735 Palomar Avenue, Sunnyvale, CA 94086. Phone (408) 735-9660. *Europe:* Systron-Donner, Munich W. Germany, Leamington Spa U.K., Paris (Le Port Marly) France. *Australia:* Systron-Donner, Melbourne.

SYSTRON DONNER

READER SERVICE NUMBER 32

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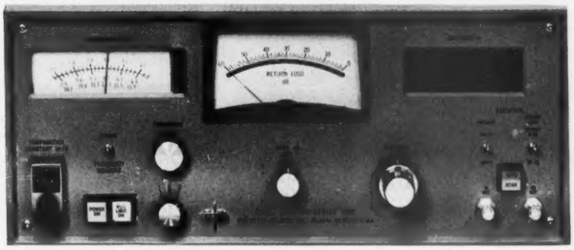

Now you can locate and measure faults in your waveguide system. The auxiliary recorder gives a permanent record of return loss as a function of distance. You can determine the nature of the fault in seconds—broken transmission line, misalignment, etc. and readily determine corrective action. The return loss profile recorder provides a record to measure system performance over a period of time. Thus you can spot early signs of corrosion and plan remedial action before faults become troublesome. Avoid expensive emergencies.

The fault locator can be used in both waveguide and coaxial cable systems. It is a lightweight, portable, self-contained measurement system complete with necessary RF signal sources. Many optional items available to adapt it to specific needs and requirements.

We welcome the opportunity to send you more complete information, or, perhaps, arrange a demonstration. For full details phone or write, Scientific Atlanta, Inc., P.O. Box 13654 Atlanta, Ga. 30324. (404) 938-2930. Or call one of our regional offices in the following cities: □ Atlanta, Ga. (404) 938-2930 □ Belleville, Ill. (618) 397-9251 □ Bladensburg, Md. (301) 779-1515 □ Burlington, Mass. (617) 272-1256 □ Dallas, Tex. (214) 357-1855 □ Denver, Colo. (303) 321-2483 □ Leonia, N.J. (201) 461-5340 □ Long Beach, Cal. (213) 428-7515 □ Los Altos, Cal. (415) 941-1616.

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0.5–1.0	2.5	25	+10	VSP-7431A
0.5–1.0	2.5	40	+10	VSP-7431K
1.0–2.0	3.5	25	+10	VSL-7441A
1.0–2.0	3.5	40	+10	VSL-7441K
2.0–4.0	4.5	25	+10	VSS-7451J
2.0–4.0	4.5	40	+10	VSS-7451K

*Gain variation for all units is ±1.0 dB. Maximum input and output VSWR is 2.0:1.

For communications systems:

Frequency Range (GHz)	Maximum Noise Figure (dB)	Minimum Gain* (dB)	Power Output at 1 dB Compression (dBm)	Type Number
0.47–0.89	2.5	25	+10	VSP-7431D
1.54–1.66	3.5	25	+10	VSL-7441F
1.7–2.4	3.5	25	+5	VSL-7441N
3.7–4.2	5.0	40	+7	VSG-7421R

*Gain variation for all units is ±1.0 or less. Maximum input and output VSWR is 2.0:1.

For radar systems:

Frequency Range (GHz)	Maximum Noise Figure (dB)	Minimum Gain* (dB)	Power Output at 1 dB Compression (dBm)	Type Number
1.1–1.4	2.25	25	+5	VSL-7441M
2.7–3.1	3.5	25	+5	VSS-7451N
3.1–3.5	4.5	25	+7	VSS-7451T

*Gain variation for all units is ±1.0 or less. Maximum input and output VSWR is 2.0:1.

Most of the units listed here measure only 1″ x 1″ x 3.5″ less connectors and require +15 Vdc for operation. Amplifiers can also be supplied for operation from line voltages or other d-c sources. They can be supplied to meet the requirements of MIL-E-5400, Class II and MIL-E-16400 as a minimum. A wide variety of options are available. For details, contact any of the more than 30 Varian Electron Tube and Device Group Sales Offices throughout the world or call (415) 493-4000, Extension 3746.

varian

READER SERVICE NUMBER 34

for your personal interest...

For the past ten years, MicroWaves has been serving the microwave engineer with articles on how to do his job better. We now include a column to aid you with items that entail business, travel, and financial aspects. We would appreciate your comments.

Look for air fares to go up with the coming new year. Lack of fuel and massive lay-offs have resulted in less flights and those that remain will have an approximate increase of 5% on domestic flights, 6% on North Atlantic flights and 12% on Youth fares for North Atlantic flights (approximately $30 higher than the current fare). If you encounter difficulties in securing a firm reservation, it would be wise to try standby. This should not be a major problem with transcontinental flights but commuter flights have had the most serious cutbacks.

In the short-term future, houses will have a warranty. Cost will be about $2 for each one thousand of the price. The benefits are plenty-full protection against any problem in the workmanship or defective materials for the first year; protection on defective structure and electrical, heating, cooling and plumbing for the second year; and protection on major construction problems for the next eight years. This responsibility lies with the builder—if he should close his business your insurance company will then handle all problems.

"Pocket Guide to Choosing a Vocational School" might be of interest to either you or your children. It helps in avoiding those courses which train you for skills that are no longer in demand or about to become obsolete. Also included is a payment of fees. Write to: Federal Trade Commission, Consumer Information, Pueblo, CO 81009.

Involved in a car pool? If you are working your pool on a profit basis, check into your car insurance. The driver in this situation often is required to register as an omni-bus. Remember also that should you be involved in a serious accident, you will most probably be sued. Insurance agents advise that you carry bodily injury liability of $100,000 per injury and $300,000 per accident. Many people are already covered under such a plan. Also look into medical payments for each individual who is a passenger in your vehicle. If you do have to increase your insurance to add this coverage, the estimated cost is from $25 and up.

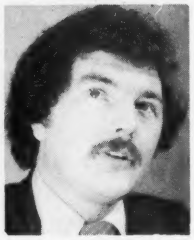
It's time to get yourself into shape for the ski months. It is estimated that many accidents could be avoided or will result in less serious injury if you exercise properly before attempting the sport. Recommended are a varied set of exercises which should include: leg lifts, deep knee bends, toe stands, sit ups, etc. Add to this some jogging or running. As with any exercise, begin slowly at first and gradually increase the number. Limbering yourself before you ski will add to both your health and enjoyment.

You might want to acquaint yourself with the newest types of contact lenses on the market. At present, there are three types available: hard or regular, semi-soft and soft. Many people fear the adjustment and the care involved for lenses. One optometrist states that lenses give their wearers a significantly broader scope of vision than do glasses—with good or better vision.

The difference among the three is adaptability, care and cost. The least expensive and the oldest on the market are the hard lenses. They are also quite easy to care for. Their main drawback as opposed to the others is that they are somewhat difficult to first adapt to. Semi-soft lenses are as easy to care for as hard lenses combined with quick adaptability of the soft lenses. Soft lenses are the most comfortable, have easy adaptability but they must be sterilized once a day and are the highest in cost. Hard lenses range from $125 to $250 a pair and semi-soft and soft are $250 up to $400 a pair. Wearability is longest for the hard lenses—up to five years, the remainders should be replaced every two years. Insurance rates range from $17 per year on the hard lenses and $30 per year for the soft and semi-soft. —S.L.B.

editorial

Opportunity knocks. Can you open the door?



This month's special report points up the demands being placed on the microwave semiconductor industry for low-cost power transistors to supply the newly created 900 MHz mobile-communications market. This need evolves from spectrum crowding at the hf, vhf and low uhf bands. The need for new spectrum allocations is clearly warranted, but the question remains: can the microwave industry deliver a 1 GHz device in volumes of thousands per week at a price of $1 a watt?

The mobile radio manufacturers realize that microwave industry has the technology, but doubt if they can meet volume production and price specifications. Semiconductor manufacturers are responding to this challenge by devoting extensive R&D efforts toward developing a suitable device. The problem, according to many manufacturers, lies in developing an economic package. Presently, many power transistors designed for 1 GHz are for solid-state phased array and require elaborate packaging schemes in order to achieve ultra-wide bandwidths. In land-mobile applications, however, a higher level of parasitics can be tolerated since the application is essentially narrow band. Prototypes exhibited by several companies feature simple packages that are not only cheap to build, but lend themselves to mass-production techniques.

The technology is there, but the manufacturers say that in order to lower costs, they must have incentives and commitments for volume production.

A similar situation exists in the military's reluctance to endorse large scale solid-state phased array programs. Manufacturers are still expected to prove reliability but cannot really do this economically and on the massive scale required without a firm government commitment.

What is needed, in both cases, is an expression of mutual confidence—backed by dollars. Transistor manufacturers must honestly assess their manpower and facilities in order to make accurate appraisals available to purchasers. The systems people, on the other hand, must somehow demonstrate that their need is real and must supply firm commitments as early as possible. No one likes to rely on empty promises.

The year of giant growth for land-mobile communications could also be the year of great opportunity for the microwave semiconductor industry, if they are up to it.

Stacy V. Bearse

Associate Editor

The Year Of Giant Growth Arrives For Land-Mobile Communications

Photo courtesy of New York Convention and Visitors' Bureau

> **WANTED:** Semiconductors. Power transistors capable of handling 10-35 W at 806-947 MHz. Need 7-dB nominal gain. Transistors must use 12.5-Vdc bias and withstand severe shock and temperature specs. Willing to order thousands weekly at about $10 apiece. Address all replies to the Land-Mobile Communications Industry.

The ad is hypothetical, of course, but the need is real, brought on by a critically crowded land-mobile communications spectrum. The last major spectrum allocation to land mobile users was in 1948, when there were 83,000 licensed transmitters. Today there are five million users, all packed, sardine style, into the same spectrum, and their numbers are growing 20% a year.

Those affected by this spectrum squeeze range from the executive who must wait several years for a mobile-phone license to policemen and firemen, whose very lives hinge on reliable communications. In September, 1972, Patrolman Anthony Raymond spotted a suspicious car cruising on the Eisenhower Expressway near Hillsdale, IL, a suburb of Chicago. Stopping the car for a routine check, the officer began to radio the license number back to headquarters, but he was knocked off the band by other users. His transmission was never completed. Hours later, his car was found empty. Months later, Patrolman Raymond's body was found buried in a shallow grave in the mountains of northern Wisconsin.

Stacy V. Bearse
Associate Editor

To prevent tragic mobile communication failures like this, to pump vitality into an all but choked branch of communications, Government and industry are working on several fronts to expand the spectrum. Among the major steps they are taking are these:

- The FCC has reallocated a band 115-MHz wide between 806 and 947 MHz, originally earmarked for uhf television, to land mobile. The highest band now in nationwide land-mobile use is 450 to 470 MHz.
- System proposals for the new band are centered on breaking down large transmitting areas into "cell" areas. By restricting mobile communications to each cell, designers aim to increase the number of times a channel can be used within a large area. A vastly expanded mobile-telephone system and a new portable telephone that can be carried in an attache case are envisioned.
- Major mobile manufacturers —RCA, GE and Motorola—are developing miniaturized frequency synthesizers as key components for the proposed high-capacity systems.
- Semiconductor manufacturers, responding to a clamor from equipment designers for low-cost power semiconductors, are pushing the development of a new class of microwave transistors.
- As industry eyes the 900-MHz band, it plans circuitry heretofore foreign to commercial communications. Beam-lead technology, varactor multipliers, silicon-on-sapphire chips and LSI circuit techniques are being considered to cope with the stringent multi-channel requirements.

Three major proposals weighed

Three proposals filed recently with the Federal Communications Commission illustrate the tremendous potential of the newly created band. Two of the designs—one by Motorola, the other by AT&T—encompass radio-telephone systems. The third proposal, by General Electric, suggests a new private dispatch service in which many users can time-share a few channels through a central computer.

The Motorola and AT&T plans (Fig. 1) would subdivide large mobile-telephone coverage areas, now about 100 miles across, into small cells, each typically two to eight miles wide. A set of channels would be assigned to each cell. The range of transmitting bases and mobile units would essentially be limited to each cell, thereby allowing reuse of the channels in other, nearby cells.

For example, a city now covered by only one transmitter would be broken down into many cells, the size depending on expected subscriber density. In the Motorola system, called Dynatac, one transmitter would cover each cell, and it would be tied in with satellite receivers distributed throughout the area. In the AT&T system, called Hi-Cap, transmitter/receiver base stations would be placed at alternate corners of hexagonal cells. As the mobile units in both systems moved from one coverage cell to another, they would be "handed off" to a new base station and automatically assigned to an appropriate channel by a central processor.

The Motorola and AT&T systems differ in their potential users and in bandwidth specifications, as well as in cell structure. AT&T has petitioned the FCC for exclusive use of a 75-MHz-wide band from 806 to 881 MHz—nearly 65% of the newly allocated spectrum—to combine mobile and portable telephone and dispatch services into an expanded mobile-telephone system. Robert Mattingly, head of the Mobile Systems Development Dept. at Bell Laboratories in Whippany, NJ, explains that 64 MHz would be used for land-mobile communications and 11 MHz for air-to-ground links. The system would have 800 channels, with 40-kHz channel spacing and 12-kHz deviation. AT&T has no plans to manufacture the mobile-radio equipment but intends to concentrate on transmitting and switching messages.

Motorola, on the other hand, is proposing to supply the equipment and design know-how to interested managers. Its system is based on 1-W, hand-held duplex radio-telephones. Prototypes of these battery-powered portables can be carried in attache cases. They are completely self-contained and allow users to make or receive phone calls wherever they happen to be.

Motorola has asked the FCC for a 19-MHz-wide allocation to establish a trial system in New York City. The first subscribers would be served late in 1976. Bob Waltz, a spokesman for Motorola Communications in Schaumburg, IL, describes the Dynatac concept as a special case of mobile telephone. "It is not," he says, "a replacement for either vehicular mobile

(continued on next page)

Two main mobile setups

There are two major classes of land-mobile communications: private dispatch and public correspondence.

The majority of users rely on private dispatch. Such radios are used by public service departments, transportation services and private businesses to communicate between one fixed base station and several vehicles. Typically users provide their own equipment and have the exclusive use of a private channel, 20 kHz wide, in bands falling between 25 and 50 MHz, 150 and 160 MHz and 450 and 470 MHz. Some land-mobile users in the 10 largest metropolitan areas also share a band from 470 to 512 MHz with uhf television.

The total land-mobile allocation is about 40 MHz wide, and the Federal Communications Commission reports that there are now over five million licensed private-dispatch transmitters in this spectrum.

Private dispatch is characterized by short messages that last, on the average, about 15 seconds. Transmission is usually simplex and two-way.

The second category of land-mobile communications, public correspondence, includes mobile telephone. A mobile telephone is essentially a dispatch radio with 12 channels and a means of addressing a special base station. The systems are maintained by specialized common carriers.

The public-correspondence base station is interfaced with the nationwide telephone network, and provides switching and billing for mobile calls. Subscribers to a mobile-telephone service provide their own radio-telephone and pay a monthly service fee ranging from $40 to $50 to the common carrier. Although AT&T and affiliated Bell systems operate most mobile-telephone services, they do not manufacture mobile equipment. Motorola, RF Communications and General Electric are the major suppliers.

Mobile-telephone transmission is duplex, allowing the user to transmit and receive simultaneously. In contrast with the average 15-second dispatch mesages, telephone conversations average between two and three minutes.

Both types of land-mobile communications use FM transmission. FM is preferred mainly because of its superior "capture" qualities. Capture simply means that if a receiver is subjected to two FM signals of nearly the same frequency, it will latch onto the stronger and virtually reject the weaker, thereby minimizing co-channel interference. AM is impractical because of the extreme fluctuations in signal strength encountered by a mobile vehicle speeding through a coverage area. ••

LAND MOBILE TECHNICAL SPECIFICATIONS

	Frequency Band		
	150 MHz	450 MHz	900 MHz
Mobile Transmitter	60 W	40 W	20 W
Base Antenna Gain	6 dB	10 dB	13 dB
Base Receiver Noise Figure	10 dB	10 dB	13 dB
Transmission Line Loss	1 dB	2 dB	3 dB
Terrain Loss Function (90% Data)	22 dB	35 dB	43 dB
Average Noise Level	0	−5	−15
City Factor; Foliage Loss	10 dB	28 dB	34 dB
Maximum Power Permitted	600 W (a)	1000 W (b)	(c)
Channel Bandwidth	20 kHz	20 kHz	(c)
Frequency Deviation (Each side of Center)	5 kHz	5 kHz	(c)
Frequency Stability	0.0005%	0.00025-0.0005%	(c)

(a) Input to Final Stage (b) Effective Radiated Power (c) Not Specified

telephone or private dispatch."

The GE system, called Multiple User Private Dispatch Service, is designed to make shared private dispatch more economical for small users. At present approximately 70% of all commercial urban vehicles belong to fleets of five vehicles or less. Yet only 10% of all licensed mobile transmitters are found in the small fleets. The reason, according to Glenn Peterson, general manager of GE's Mobile Radio Div. in Lynchburg, VA, is cost. The small businessman simply cannot justify the expense of base-station equipment, towers, antennas and mobile radios.

Traditional shared-dispatch systems involve as many as 50 users sharing a single channel. Each user owns his own base and mobile equipment. Communications are generally not private, and users must wait until the channel is clear before they initiate a call. GE's plan promises to reduce drastically the equipment needed by a user, because everyone would share the same base station.

Instead of a radio, subscribers in the GE system would be provided with a keyboard console, which would be connected to a central computer-controlled base station by a wire link. To talk to a mobile unit, the subscriber would address the computer by tapping in an appropriate code. The computer then would search through a group of channels, looking for an opening. When a channel became free, the base would transmit a control signal, which would place the mobile unit on the proper channel, thereby completing the communication link.

Its system, GE says, would double the message potential of present systems and typical user costs for small fleets would range from $35 to $60 a month.

GE has applied for permission to build a trial system in Dallas, TX. With favorable FCC action, the system could be operational next year, the company says. According to Bob Gordon, manager of advanced development engineering for GE Mobile Radio, the system would have initially four voice channels plus one control channel, but it could be expanded to 64 channels. Channel spacing would be 25 kHz. In oral arguments, Peterson told the FCC that such a system, serving 200 users and 800 mobiles, would cost about $1-million to build.

Improved equipment needed

Obviously the systems people

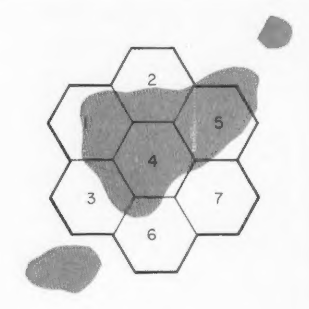
Cell structures key to spectrum conservation

If you live near a major city, call the telephone company service office and request mobile-telephone service. Chances are, your application will lie dormant on a waiting list for a year or two until someone who already has mobile service decides to give it up. The inherent design of present systems along with a meager spectrum allocation (less than 1.5 MHz total) limit this desirable service to less than 90,000 subscribers nationwide.

Today's mobile-telephone systems use one 12-channel transmitter/receiver to cover a 50-mile radius. With 30-40 subscribers per channel, this means that only about 400 subscribers can be accommodated within a 7,850 square-mile area. Also, only 12 simultaneous conversations are possible in any given area.

To further illustrate the current mobile-telephone situation and the relief afforded by the 900 MHz band, consider the following: The state of Pennsylvania currently has about 2,274 mobile-telephone subscribers. The city of Philadelphia alone has 1,684 applications waiting for space on its mobile-telephone system. AT&T's Hi-Cap plan, implemented in the 900 MHz band, can eventually accommodate over 340,000 subscribers in that city alone.

Bell's system takes a large coverage area now handled by a single transmitter/receiver base station and breaks it up into a honeycomb of smaller hexagonal coverage cells. Thus, a city that is now served by one base station might be divided into seven distinct coverage areas (Fig. 1(a)). Bell engineers plan to place low-power (10 W) base stations on alternate corners of each hexagonal cell and cover portions of three adjacent cells by means of highly-directional antennas. All base stations will be connected, by wire-line, to a central mobile-switching office.



1(a)

Bell would also take its total channel allocation and divide it into seven groups. Each coverage cell would be assigned one channel subgroup. Our hypothetical city is now covered by a grid of 7 coverage cells, each using a distinct group of channels.

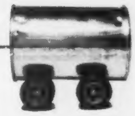
Mobile units would be equipped with 10-W transmitters and would employ frequency synthesizers instead of the crystal-controlled oscillators presently used. The synthesizers would be controlled by a logic center located inside the vehicle's radio. During a conversation, a computer in the mobile-switching office would track the vehicle by comparing signal strength information received from several base stations. If the computer detects that a subscriber has moved from one cell to another, it would instruct the base station receiving the strongest signal to transmit data, over a control channel, instructing the mobile's frequency synthesizer to change to an open frequency in this new cell's channel subgroup.

Break it up

The major advantage of the Hi-Cap system is its ability to grow with demand without using up any more spectrum space. Consider the city that was broken down into seven cells in the earlier example. Allowing 7 subscribers per channel, some 5,600 could be handled city-wide.

As the city-wide demand for mobile service approached this figure, the size of the coverage cells would be decreased, the customer-to-channel ratio would be increased and more cells would be added. The cell structure would be changed by adding more base stations and adjusting their range and radiation pattern to define a new cell network.

By repeating this seven-cell grouping over and over, more subscribers could be accommodated without using any more spectrum bandwidth.



have been very active. They are challenging equipment designers and semiconductor manufacturers to keep pace. Ask a land-mobile engineer where the challenges are, and he will probably mention these areas:

- Remedies for more complicated propagation losses.
- New logic and frequency synthesizers to cope with multichannel requirements.
- New power semiconductors that are competitive in performance and cost with those now used at lower frequencies.

Propagation tests conducted by RCA's Communications Div. in Meadow Lands, PA, indicate that the characteristics of 900-MHz transmission (Fig. 2) are similar to those of 450 MHz, with a few noteworthy exceptions. The tests were conducted in the Pittsburgh area, with a remotely operated base station atop a 400-foot bluff and a van equipped with receiving, measuring and control equipment. Co-linear arrays were used as base antennas, and they put out some 560 W of effective radiated power. A side-by-side comparison of propagation over "rolling hills, deep valleys and thick tree cover," RCA reports, shows that, in general, the propagation loss at the higher frequency is 8 dB greater.

Under typical conditions, coverage was observed to be virtually similar for 450 and 900 MHz. Measurements were taken along two belts, 10 and 20 miles from the base station. As seen in the accompanying table, 97% of the signals measured along the belt 20 miles from the base station were usable at 450 MHz and 89% at 862 MHz. Along the ten-mile belt, 99% of the signals were usable at 450 MHz and 96% at 862 MHz. A usable signal was defined as one of greater than 0.25 μV.

In a paper delivered last month to the IEEE Vehicular Technology Conference in Cleveland, Andrew M. Missenda, manager of advanced development engineering at RCA, said: "The 900-MHz band may offer some significant coverage advantages over the existing band in such city areas as long tunnels and under elevated roads and railroads."

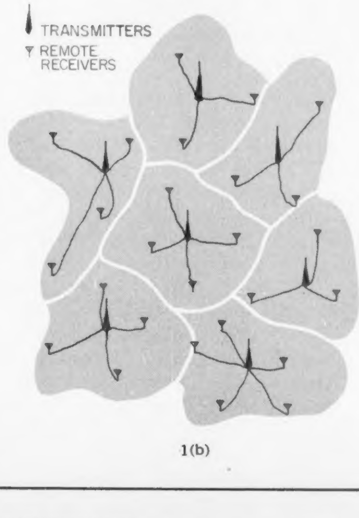
Missenda found that in various tunnels in the Pittsburgh area the signal strength was as much as 15 dB greater at 900 MHz than at 450 MHz. He attributes the surprising improvement to a more highly scattered signal illumination at the tunnel entrance and multiple reflections along the tunnel walls.

(continued on next page)

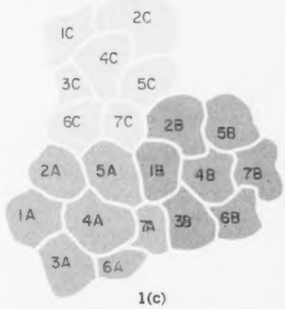
Cells tailored to area

Motorola's Dynatac system also uses small coverage zones, but, unlike AT&T's hexagonal cells, they are not symmetrical. Rather than impressing a fixed cell pattern over a given area, Motorola engineers would let an area's propagation characteristics and projected subscriber density dictate the size and shape of each cell.

"To set up Dynatac coverage, (Fig. 1(b)) the first thing that you want to do," says Martin Cooper of Motorola, "is to be able to reach portables anywhere in the city. You must lay a network of base station transmitters such that you have complete coverage. Now, considering that the base transmitter is much more powerful than the 1-W portables, you must blanket the city with receivers so that no matter where a portable is, he may be received. Groups of receivers are then associated with base transmitters, and the entire system is connected to a central control center that makes transmitter, receiver and channel assignments to each portable."



1(b)



1(c)

A base station transmitter and the satellite receivers associated with it would comprise a coverage cell.

Motorola proposes to divide the total number of available channel pairs (380 for a trial New York City system) into seven unequal groups. Every cell would be assigned one group of channels. The groups containing many channels would be assigned to cells covering areas of exceptionally high usage.

As in the AT&T proposal, a pattern of seven coverage cells would use up all available channels and the system would be expanded in much the same way as a Hi-cap system; by repeating the same seven-cell pattern over and over again.

Motorola uses a terciary offset frequency technique to counteract the potential for co-channel interference caused by using a 25-kHz channel spacing. Each channel is divided into three subgroups. All channels in the A subgroup are offset 8.33 kHz below the original channel's center frequency. Channels in the B subgroup are at the center frequency while channels in the C subgroup are offset 8.33 kHz higher. In designing a coverage scheme, all channels of the A subgroup would be assigned to a seven-cell grouping. As the seven-cell pattern is repeated, channels from the B subgroup would be used. If a third seven cell pattern is required, it would use channels from the C subgroup. By building up coverage in this manner, no adjacent seven-cell groupings would use channels having exactly the same center frequency (Fig 1(c)). Motorola engineers claim that this technique decreases the level of co-channel interference by 20 dB.

As subscribers move from cell to cell, channel reassignments would be made in much the same manner as in the Bell system and occur within a time frame of 25 milliseconds.

RCA engineers found similar enhancement along the steep banks of local rivers. Fred Barton, a senior advanced development engineer for RCA, concludes: "On the basis of our tests, we have recognized some problems of 900-MHz propagation, but they are not insurmountable. The 900-MHz dispatch systems will be practical in the near future."

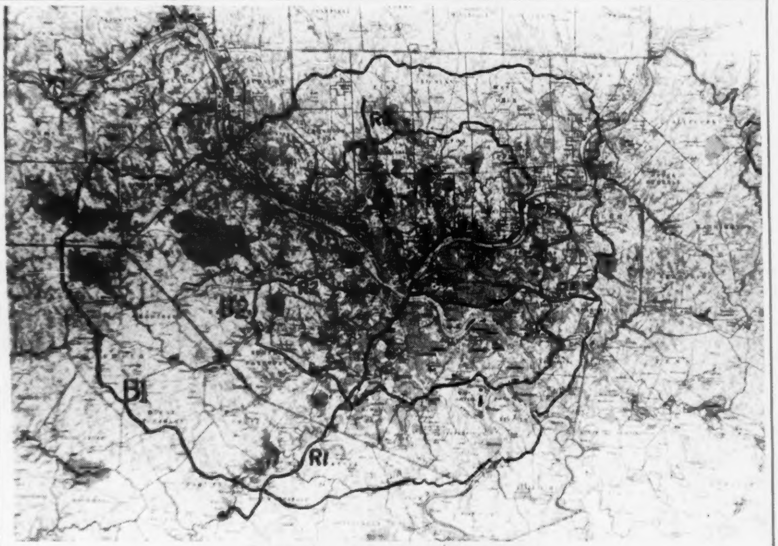
Motorola has been conducting propagation tests in New York City, Washington, DC, and Chicago. The tests were aimed at evaluating propagation parameters that might influence a cellular-coverage system. They showed that manmade structures can seriously affect propagation. Big buildings, the report concludes, can cause large and random fluctuations in signal strength over a small area. Peak-to-peak variations of up to 35 dB were observed.

Since Motorola is interested in marketing hand-held radio-telephones, its designers must consider propagation losses when broadcasting into or out of a building. Very little published data exists on building losses at 900 MHz, but tests by the FCC indicate that a 35-dB loss would have to be overcome. The tests were based on transmission from street level to an interior, second-floor hall.

In its application before the FCC, Motorola concludes that cellular systems must be tailored to widely varying local characteristics to minimize co-channel interference and cost and spectral inefficiencies.

GE's tests predict that the propagation loss at 900 MHz would be 10 dB greater than at 450.

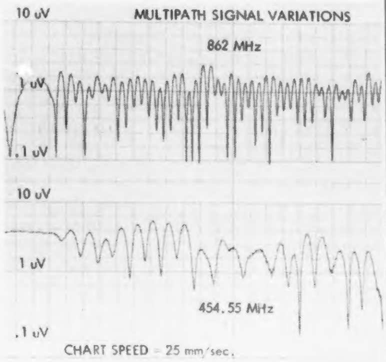
Further work on predicting 900-MHz propagation characteristics has been done by Schultz[1] and Okumura and associates.[2]



Percent of Points Measured

Signal Strength	Belt 1 450 MHz	Belt 1 862 MHz	Belt 2 450 MHz	Belt 2 862 MHz
Good (> 1.0 μV)	79	54	85	62
Usable (> 0.25 μV)	18	35	14	34
Not Usable (< 0.25 μV)	3	11	1	4
At Least 0.25 μV	97	89	99	96

(a)



(b)

2. **Propagation measurements** along two test belts (a) indicate little difference in coverage between 454 MHz and 862 MHz. Multipath signal variation (b), resulting from a vehicle moving through a standing-wave pattern created by the vector sum of many reflected wave fronts, occurs at about twice the rate for the higher frequency, as expected. Note that signal strength is about 8 dB less at 862 MHz.

A key role for frequency synthesizers

Because of the vast number of channels about to open, most mobile-communications engineers agree that frequency synthesizers will play an important role in telephone and dispatch services at 900 MHz. AT&T's Hi-Cap system requires an 800-channel potential. Motorola's Dynatac demands 380-channel agility, and GE's Multiple User Private Dispatch Service eventually would need mobile units with 64-channel capability.

Designing synthesizers for base stations where size and power drain are not very crucial does not seem to present a problem. "The challenge," according to Missenda at RCA, "is designing for a portable. There is a speed-power drain trade-off to be concerned with. Operating in the region of 900 MHz, existing synthesizers require a lot of current."

Tom McKee, manager of mobile and station engineering for GE in Lynchburg, notes that many instrumentation synthesizers draw in excess of an amp. He indicates that present land-mobile crystal-controlled transceivers draw about 150 mA on standby. The synthesizer must not add appreciably to this and, in any case, not raise the total current drain above 500 mA.

"The key to successful design is to find a micropower technique comfortable at high speeds," Missenda continues. He suggests silicon-on-sapphire circuitry.

Motorola seems to have the synthesizer technology ironed out in its Dynatac portable, although it won't discuss cost. A digital synthesizer referenced to a 2.5-part-per-million crystal oscillator and controlled by a supervisory logic center can generate about 380 distinct channel pairs. Motorola is re-

(continued on p. 44)

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luctant to discuss details, but it admits that the VCO and dividers are made with LSI circuits and CMOS circuitry techniques.

Wanted: Economical power semis

The limited availability of power semiconductors in the 900-MHz region is described by many radio designers as the factor that could limit the success and growth of this band. Basically the designers are calling for 12-V transistors capable of handling 10 to 35 W and giving typical gains of about 7 dB between 806 and 947 MHz. Technically this is certainly feasible. However, since the land-mobile market is consumer-oriented—and therefore very cost-conscious—these transistors must be priced competitively with devices used in the 450-470-MHz band—roughly $1 per watt.

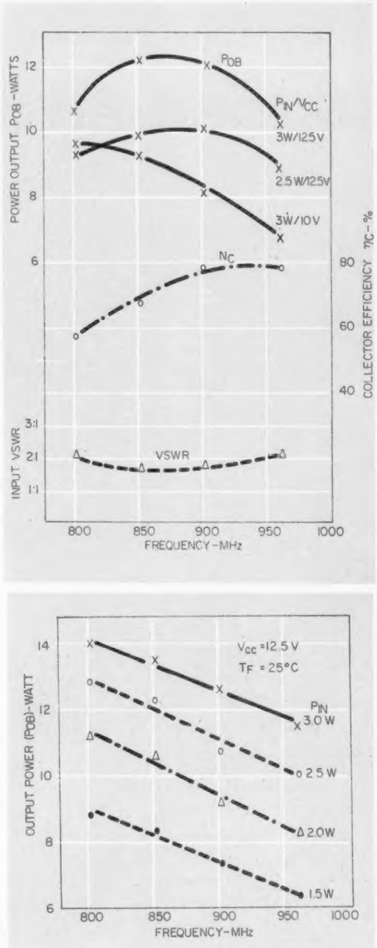
"Right now, there are no suitable semiconductors in volume production that are practical and have sufficient power," says Martin Cooper, vice president and director of systems operations at Motorola Communications.

Tom Moutoux, vice president of engineering at Communications Transistor Corp., San Carlos, CA, says: "I can understand the radio manufacturers' concern. Looking at the market for microwave transistors today, about the lowest price for a 20-W product is $150, with manufacturers delivering only one-to-nine quantities. We must be prepared to deliver thousands per week at about $20. This cannot be a microwave transistor. A new transistor, involving microwave construction techniques with innovative packaging, must evolve."

GE's McKee feels that the biggest single challenge in designing commercial equipment for the new band is generating adequate rf power economically.

"Not only are the transistors currently available more expensive at 900 MHz," he notes, "but because they don't have the gain of lower-frequency devices, it takes more of them to reach a given power level. There are, of course, some alternatives to the all-transistor transmitter. Varactor multipliers, for example, are standing by in the wings in case the transistor prices aren't attractive. It's really a challenge to the vendors of rf power devices to see what can be done cost-wise."

With a Bell Laboratories study



3. These power transistor curves illustrate the kind of performance required by the land-mobile industry. The characteristics are for a 10-W prototype transistor developed by Microwave Semiconductor Corporation (model MSC 0910M) especially for the new land-mobile band. Radio manufacturers are demanding devices like this with a $10-price tag.

reportedly predicting some seven million mobile telephone users in the new band by 1980, the semiconductor industry has set up extensive R&D programs to develop suitable transistors. Most manufacturers agree that the present devices are very expensive, and although volume production would help bring prices down, some technological refinements are necessary. There are many approaches to reducing high-frequency transistor costs, but this appears certain: Packaging must change, too, and this, in turn, may modify the land-mobile industry's manufacturing techniques.

New packaging explored

"The conventional package used in the 450-470-MHz band cannot be used at 900 MHz because attenuation is a consideration," says Richard Saxe, plant manager of communications products for TRW Semiconductor Operations in Lawndale, CA. "The microwave transistor package is outrageously priced. It doesn't look like the 900-MHz devices will be in a conventional package but rather on a carrier where the customer will end up using some kind of stripline circuitry technique, much like microwave integrated circuits."

Although most land-mobile radios are now fabricated on printed-circuit boards, some manufacturers are introducing new techniques in anticipation of a change. RCA Communications in Meadow Lands, is currently using beam-lead devices, thermo-compresion welding and automated-laser trimming on its TACTEC line of 450-470-MHz portables.

Microwave Semiconductor Corp. in Somerset, NJ, has produced a number of prototypes for the 900-MHz band that are essentially 1-to-2 GHz transistors packaged to hold down costs. The company is taking the high-frequency chips, placing them in less critical packages and incorporating internal matching circuitry to make up for the bandwidth loss caused by a higher level of parasitics.

"A microwave package must be designed for minimum parasitics and is too expensive to be competitive in this application," explains John Locke, marketing applications enigineer at Microwave Semiconductor. He indicates that his company's microwave packages are designed to minimize base-to-ground and emitter-to-ground inductances, which tend to degrade bandwidth. Since land-mobile applications don't require the extensive bandwidth needed for typical microwave applications, such as solid-state phased-array radar, a device can tolerate a higher level of parasitics and still be suitable.

One Microwave Semiconductor prototype (Fig. 3) offers 11-12-W performance at 12.5 Vdc. Narrowband performance gives 6.5-7.5-dB gain and 14 W at the lower end of the 806-947-MHz band. Collector efficiency is reported to be 65 to 78% over the entire land-mobile band. The company says that this device, when produced in quantity,

(continued on p. 46)

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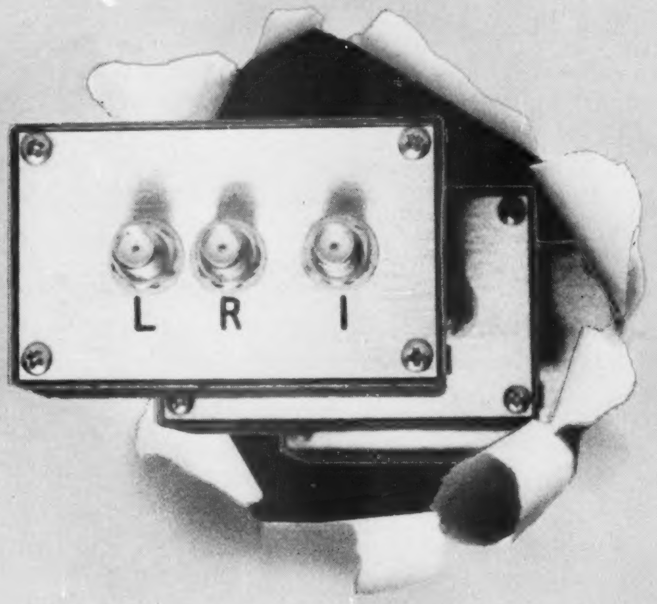

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	LO	RF	IF					LO — RF		LO — IF		LO — RF		LO — IF		LO — RF		LO — IF		
				Typ.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	
ZMA-2	1-2.5	1-2.5	DC-0.3	7.0	8.5	7.5	9.0	25	20	50	35	22	17	40	30	20	15	35	25	$49.95 (1-9)
				1.6 - 2.5 GHz		1.4 - 3 GHz		1.4 - 2 GHz				2 - 2.5 GHz				2.5 - 3 GHz				
	LO	RF	IF					LO — RF		LO — IF		LO — RF		LO — IF		LO — RF		LO — IF		
				Typ.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	
ZMA-3	1.4-3	1.4-3	DC-0.7	6.5	8.0	7.0	9.0	35	25	50	35	28	20	50	30	23	18	50	30	$54.95 (1-9)

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will be cost-competitive with lower-band devices offering similar performance.

Microwave Semiconductor has also demonstrated prototypes for 3-W drivers and 20-W outputs and, according to Locke, "a 35-W device will be no problem."

To reduce production costs, the bonding schemes of all manufacturers will have to be simplified. Some semiconductors used in phased arrays at 1 to 2 GHz require over 100 internal wire-bond leads. Saxe indicates that TRW intends to do internal matching by a patented batch-processing technique, thereby eliminating all bond wires.

The 12-Vdc bias problem

Another problem being faced by the semiconductor industry is the need for designing the transistors to operate with a 12-Vdc bias instead of the traditional 28 Vdc. Twelve volts is a natural requirement in mobile work. Since it is easily available in all land-mobile vehicles, power-supply considerations are eliminated. Jim Curtis, an applications engineer at Power Hybrids, Inc., Torrance, CA, says that by taking a 2 or 3-GHz geometry and diffusing it on low-resistivity material, good power and gain can be maintained at the 12-Vdc bias level.

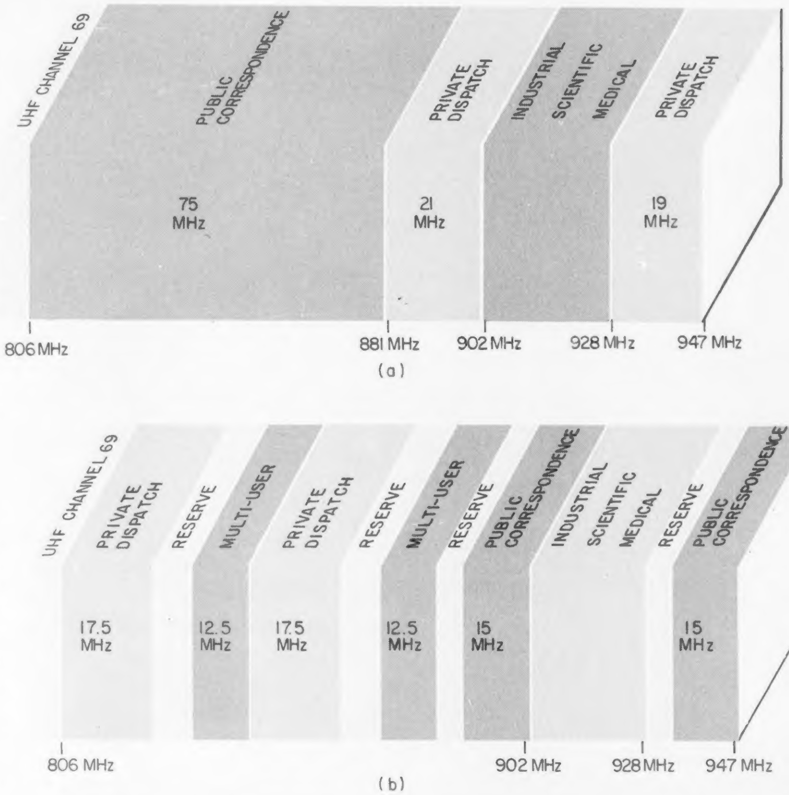
"When you diffuse on low-resistivity material," he explains, "the COB parasitic gets larger. But the fact that you've used a higher-frequency transistor having less COB, to begin with, means that you end up with good uhf power at low voltages."

Power Hybrids has demonstrated prototype modules, based on a low-resistivity, 1.5-GHz geometry, that produce 10 W with 10-dB gain at about 900 MHz.

Along with adapting to new packaging schemes, radio engineers will be faced with designing common-base circuits instead of the familiar common-emitter now used in all 450-470-MHz equipment. Common-base offers greater gain at the price of decreased stability, and it seems to be the direction that most semiconductor manufacturers are taking for the 900-MHz band.

Even with agreement on new semiconductor technology, however, some radio manufacturers foresee another difficulty: mass production. Bill Stewig, portable product planner at RCA Communications, sums up the concern this way:

"High-frequency semiconductor manufacturers may well be used to working with microwave people who don't build that many systems a year. When you start to talk about a vast increase in the number of units to produce a year, they may well find out that although they have the technology, they don't have the production capability."



4. **Although a new 115 MHz wide band** has been earmarked for land-mobile communications, it will not be used until the FCC decides on a final allocation scheme. The preliminary allocation (a) is backed by AT&T but is meeting strong opposition from the communications industry through the Electronic Industries Association. Noting that private-dispatch radios have a much longer transmitting range than the radio-telephones proposed for the new public-correspondence systems, the Association favors assigning dispatch to the lower end of the new band where the propagation losses are less. They further suggest that the two unequal bands (19 and 21 MHz) assigned to private dispatch in the preliminary allocation do not lend themselves to effective transmit-and-receive channel pairing. In their proposal, the EIA recognizes a third type of service, multi-user, and favors setting aside several reserve bands for future use.

FCC has the final word

In the final analysis, the direction taken by the land-mobile communications industry will be guided by the outcome of FCC Docket 18262. In May, 1970, (Fig. 4) the commission, in Docket 18262, reserved 115 MHz between 806 and 947 MHz for land-mobile use. At that time the Federal agency put off a decision on subdividing the new band, asking the communications industry instead for "innovative comments." In June, 1970, AT&T formally proposed that a contiguous band of 75 MHz be assigned exclusively to "wireline common carriers," leaving 40 MHz for dispatch purposes.

Late in 1970 the commission accepted AT&T's suggestion on allocation and proposed the adoption of AT&T technical standards of 40-kHz channel spacing with 12-kHz deviations. But after hearing comments from industry, the commission amended this preliminary allocation by deleting the word

"wireline," thereby including radio common carriers in the 75-MHz block.

Since then, howls of protest have echoed in the FCC chambers. Representatives from the communications industry have called the allocation inflexible and spectrally inefficient. The Department of Justice, through its antitrust division, has warned that combining dispatch and telephone services might lead to another Bell monopoly. In a letter to the FCC chairman, Dean Burch, Assistant Attorney General Thomas E. Kauper warned that the allocation of an entire 75-MHz band exclusively to the wire-line carriers would have a pronounced anticompetitive effect.

The letter went on to admonish the commission to consider carefully whether the AT&T's system's "near-term saving to users would clearly outweigh the long-term benefits, which would be achieved from technical and economic competition."

Equipment manufacturers, fearing the loss of new dispatch radio markets, are equally distressed with the preliminary allocation. The Electronic Industries Association, whose members include Motorola, RCA and GE, has petitioned the FCC to modify its decision and give more consideration to dispatch services. In oral arguments before the commission, the EIA cited predictions that by 1990 the number of dispatch users would outnumber mobile-telephone subscribers 5 to 1. AT&T's plan, the EIA says, is too elaborate and costly for the average user. The industry association favors the following breakdown of the new 115-MHz-wide band:

- 35 MHz for individual private dispatch.
- 25 MHz for multi-use private dispatch.
- 30 MHz for mobile telephone.
- 25 MHz to be held in reserve.

In addition the EIA takes issue with AT&T's proposed technical specifications and asks that 25-kHz channel spacing and 5 kHz-deviation become standard.

AT&T insists that 40-kHz spacing with ±12-kHz deviation is necessary to suppress co-channel interference in a cellular system. In rebuttal, an EIA spokesman, Harold Jones of RCA, has told the commission:

"Extensive practical field trials, dynamically comparing the 25-kHz and 40-kHz ratios, have shown negligible difference in co-channel interference. The AT&T proposal provides 960 fewer channels than the EIA proposal, without a corresponding improvement in spectrum efficiency. In terms of spectrum efficiency, the EIA 25-kHz plan is 60% more efficient than the AT&T 40-kHz plan."

A third allocation plan, forwarded by the Federal Office of Telecommunications, recommends an approach that would maximize competition and minimize regulation. OTP recommends that about 40 MHz be reserved for all mobile-radio services on a competitive, non-rate-regulated basis. This would include mobile-telephone dispatch, paging and shared-user systems, Approximately 14 MHz would be allocated to wireline common carriers for tariffed mobile-telephone services and paging systems. To "provide incentives for technological innovation by means of competition," OTP recommends that the remaining 61 MHz be held in reserve and augment the initial allocations as demand for specific services increased.

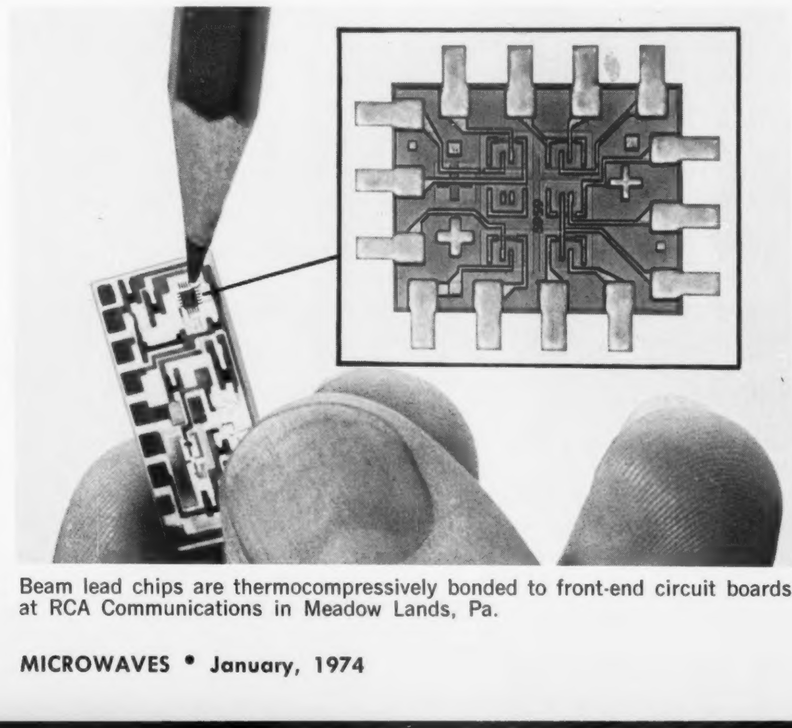
Walter Sudder, deputy director of OTP, says that the office's policy "is attempting to do away with some bad allocation practices that have crept into mobile communications." He adds:

"We are trying to get the FCC to set up broad blocks of allocations and not specifically sub-allocate them to different types of services."

One thing is clear as the communications industry prepares to jockey for final position in the 900-MHz band: the chalk talk is over. The quarterbacks have outlined their strategies and the half-time score is: Public correspondence 75 MHz, Private Dispatch 40. As the FCC contemplates the ideas before it, the communications industry waits restlessly in the locker room.

The second half begins early this year, when the commission is expected to render a final decision. If AT&T's plan wins, communications manufacturers will have to supply a huge mobile-telephone market. If the EIA plan triumphs, the market for private-dispatch equipment should skyrocket.

Whatever the decision, there will be a lot of winners. ••



Beam lead chips are thermocompressively bonded to front-end circuit boards at RCA Communications in Meadow Lands, Pa.

Bibliography

1. Schultz, C. J. *A Simplified Approach to a 960 Mc. Multi-Channel Radio System.* A.I.E.E. Fall General Meeting, Chicago, Ill., Oct., 1955.
Schultz, C. J. *Is 960 Mc Suitable for Mobile Operation?* IRE National Convention, March, 1956, New York City, N. Y.
Schultz, C. J. *900 Mc Mobile Developments.* Southwestern I.R.E. Conference, Houston, Texas, April, 1957.
Schultz, C. J. *900 Mc—A Potential Vehicular Communication Band.* WESCON Convention, San Francisco, California, August, 1957.
2. Okumura, Ohmori, Kawano, and Fukuda. *Field Strength and Its Variability in VHF and UHF Land Mobile Radio Service Review of the Electrical Communication Laboratory.* Vol. 16, Numbers 9-10, Sept.-October 1968.
3. Frost & Sullivan. *The Mobile Radio Market.* New York, New York, August, 1973.
4. Missenda, A. *900 MHz and 450 MHz Mobile Radio Performance in Urban Hilly Terrain.* IEEE Vehicular Technology Conference, Cleveland, Ohio, December, 1973.

Clean Up Your Design With a Systems Approach

Microstrip lines can do more than carry a signal. At high frequencies they can transform impedances and simplify multistage amplifier design.

A common approach to multi-stage microwave amplifier design is the so-called "building block" method. That is, to consider each stage as a separate entity, working around a 50-ohm impedance level. A more realistic approach would be to connect the stages using a systems point of view, thereby eliminating any 50-ohm interstage transitions. Since transistor input and output impedances are inherently low, direct impedance transformation using microstrip techniques seems natural. This method provides an economical, uniform design by eliminating most, if not all, variable capacitors that power amplifiers customarily require.

A systems approach was used in the design of a high level two-stage telemetry transmitter. Initially, a "building block" approach was tried using 50 ohm interstage transitions. The design was found to be unstable, however, probably because the 50 ohm interstage transitions were not physically long enough to realize their characteristic impedances. Standard material sizes and temperature considerations for the 5W, 2.3 GHz power amplifier required construction on a 1/4 in. thick brass baseplate with 1 in. × 1 in. × 25 mil alumina substrates for the input and output stages and a 1 in. × 2 in. × 25 mil alumina substrate interstage. RCA models 2N6268 and 2N6269 transistors were chosen to serve as driver and power amplifier, respectively.

Matching the input

Consider the impedances of the driver transistor:

$$Z_{in} = 5.75 + j21.22 \text{ ohms}$$
$$Z_{out} = 3.60 - j6.50 \text{ ohms}$$

The input impedance 5.75 + j21.22 ohms must be matched to a generator impedance of 50 ohms. These units are biased class C so a good match is imperative. A proper way to do this, would be to transform the input impedance of the transistor to a real value via an eighth-wavelength matching section.[1] Any load impedance can be transformed into a real impedance by an eighth-wavelength transformer having a characteristic impedance equal to the magnitude of the load impedance. A quarter-wave transformer can then be used to transform this real impedance to 50 ohms. Applying the eighth-wavelength equation,

$$Z_o = \sqrt{R^2 + X^2} \qquad (1)$$

where Z_o is the characteristic impedance and R and X are the real and imaginary parts of the impedance being transformed.

$$Z_o = \sqrt{5.75^2 + 21.22^2} = 22 \text{ ohms}$$

A $\lambda/8$ line having a characteristic impedance of 22 ohms will transform 5.75 + j21.22 ohms to a real value. Using the Smith chart to find this value, the driver input impedance is normalized by dividing 5.75 + j21.22 ohms by 22 ohms to yield 0.26 + j0.97. This is entered on the Smith chart as point A (Fig. 1a). This value is then transformed by bringing it along a circle of constant VSWR, toward the generator, until it intersects the real axis, A′. In this case, the transformed impedance is 159 ohms. Using the quarter-wave matching equation[2] to match 50 ohms and 159 ohms, we have

$$Z_o = \sqrt{Z_1 Z_2} \qquad (2)$$

where Z_o is the characteristic impedance of the $\lambda/4$ line, and Z_1 and Z_2 are the impedances being matched. Thus

$$Z_o = \sqrt{50 \times 159} = 89.3\ \Omega$$

A $\lambda/4$ line, having a characteristic impedance of 89.3 ohms is required for the match.

An easy way to transfer these impedances into meaningful microstrip line widths is to use a well documented, graphical approach such as Schillings[3]. One need not worry about the correction factor involved because these graphs take them into consideration. Using this reference, values of 93 and 5.2 mils for the 22 and 89.3 ohm lines are obtained.

Taming the interstage

Now lets consider the impedance of the output transistor,

$$Z_{in} = 2.0 + j12 \text{ ohms} \quad Z_{out} = 3.3 - j8.9 \text{ ohms}$$

Thus, the interstage transition must match two complex impedances, 3.60 − j6.50 ohms and 2.0 + j12 ohms. It seems reasonable to try and use the eighth-wavelength concept to transform the output impedance of the driver and the input impedance of the final into real values, then matching them with a quarter-wave transmission line. Applying Eq. 1

$$Z_o = \sqrt{3.6^2 + 6.5^2} = 7.42 \text{ ohms}$$

Harlan Faller, Director of Research, Tepco Corporation, P. O. Box 1882, Rapid City, SD.

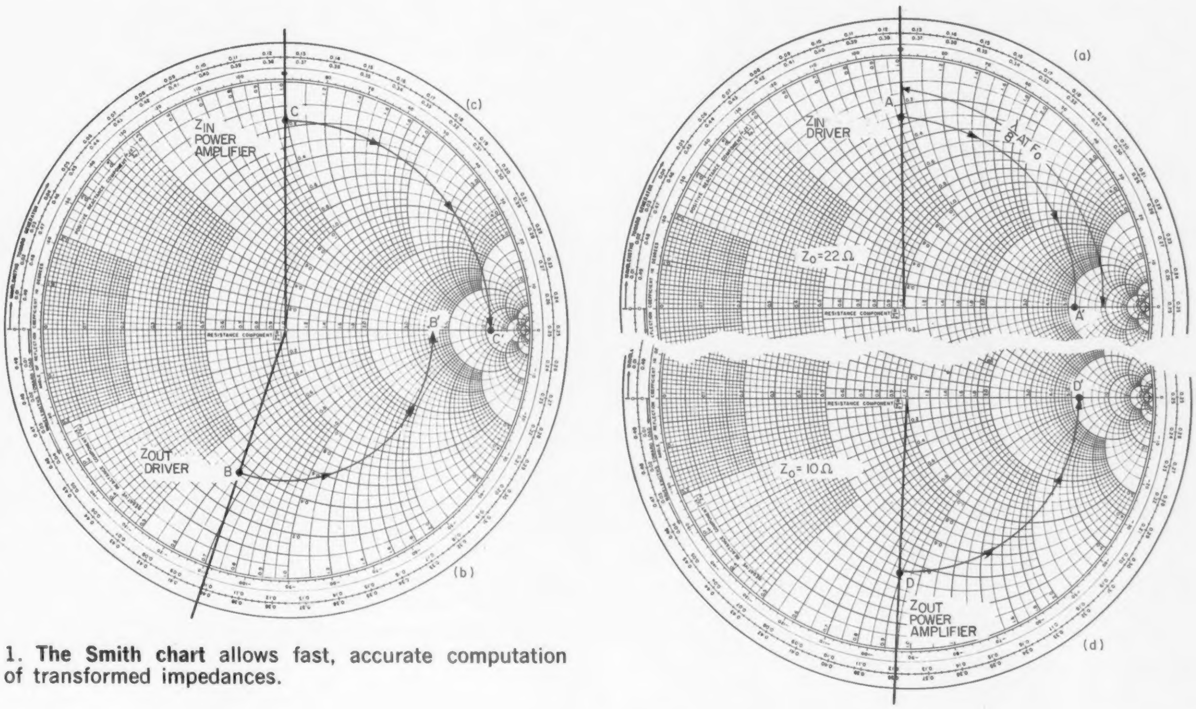
This value is too small for microstrip work because it makes the line prohibitively wide. Using 10 ohms as a reasonable approximation, the normalized complex impedance becomes 0.36 + j0.65. This value appears in Fig. 1b as point B. Rotating toward the load and unnormalizing transforms this value into a real impedance of 41 ohms. A $\lambda/8$ line, following the driver and having a characteristic impedance of 10 ohms, will present a real impedance of 41 ohms to the interstage. Applying the same techniques to the input of the final gives a 12.2 ohms, eighth wavelength line with a real input impedance of 141 ohms. The normalized value shown in Fig. 1c has been rotated toward the generator.

The next step in designing the interstage involves matching 41 ohms to 141 ohms. Normally, this can be done with a single quarter-wavelength matching section. In this case, however, a standard size (1 in. × 2 in.) substrate was used requiring the overall length of the interstage to be 2 in. This necessitated using an exponential section in conjunction with two standard quarter-wave sections, a combination that allowed the entire interstage microcircuit to be stretched across 2 in. of board.

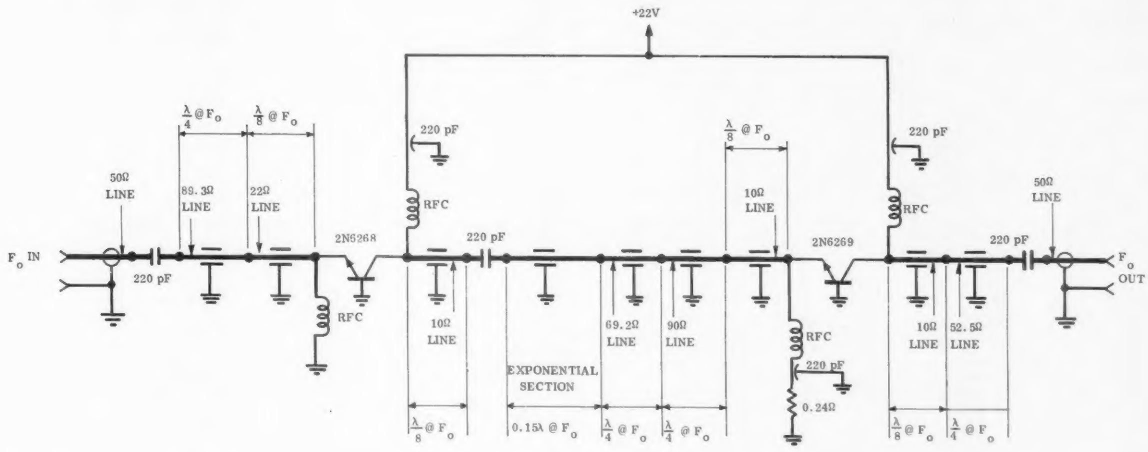
A double section, quarter-wave transformer (Fig. 3) can be described by the following equations:

$$Z_2 = \sqrt{Z_3 Z_1} \qquad Z_3 = \sqrt{Z_2 Z_4}$$

(continued on next page)



1. **The Smith chart** allows fast, accurate computation of transformed impedances.



2. **This system's approach** to high-level microwave design utilizes tuned microstrip lines to match impedances. They are shown with their intrinsic substrate capacitance. The 220 pf capacitors provide isolation and decoupling.

where Z_i refers to the characteristic impedance of a section.

In this case, Z_1 and Z_4 are known to be 41 and 141 ohms respectively. The simultaneous solution of Eqs. 3 and 4 yields values of 62 and 93 ohms for Z_2 and Z_3.

$Z_2 = \sqrt{41\,Z_3} = 62$ ohms $\quad Z_3 = \sqrt{141\,Z_2} = 93$ ohms

These impedances convert to microstrip widths of 15 mils and 4.5 mils for $\lambda/4$ lines.[3]

The exponential horn is located between the eighth-wave transformation of the driver stage and the double section $\lambda/4$ transformer. It must match real impedances of 41 and 62 ohms. The characteristic impedance (Z_o) of an exponential line has been empirically defined as[3]:

$$Z_o = \frac{377\,h}{\sqrt{\epsilon_r}\,W\left\{1 + 1.735\,\epsilon_r^{-0.0724}\left(\frac{W}{h}\right)^{-0.896}\right\}} \quad (3)$$

where W is the width of the bell (low impedance end), ϵ_r is the relative dielectric constant, and h is the thickness of the dielectric. Eliminating all insignificant first order terms and solving the equation for W gives

$$W = \frac{377\,h}{Z_o\sqrt{\epsilon_r}} \quad (4)$$

Since the wide bell end of the horn must match the real transformation of the driver's output, its characteristic impedance (Z_o) must be 41 ohms. The parameters of the alumina used in this design are:

$h = 25$ mils $\qquad \epsilon_r = 9.6$

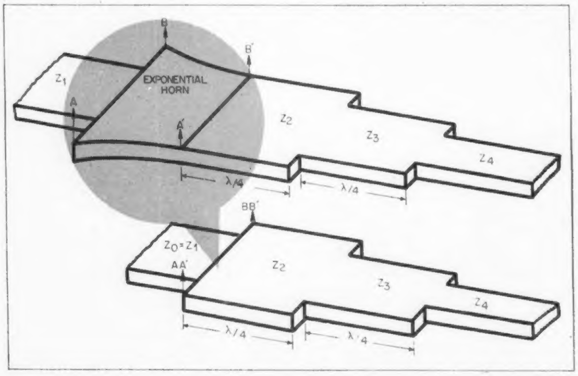
Solving Eq. 4 with these values gives a bell width of approximately 74 mils.

The horn tapers exponentially to 15 mils, matching the first section of the cascaded $\lambda/4$ transformers. The overall length of the horn is about 60% of a quarter-wave section at 2.3 GHz.[4]

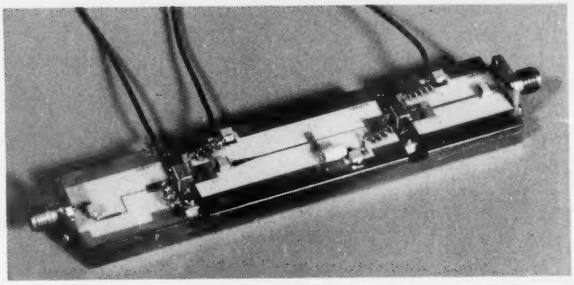
The eighth-wave equation is again used to transform the output impedance of the final collector to a real value. Application of Eq. 1 gives

$Z_o = \sqrt{3.3^2 + 8.9^2} = 9.95$

or 10 ohms as a practical value. The normalized output impedance, $0.33 - j0.89$, is entered as



3. The exponential microstrip section lengthens the interstage transformer without affecting electrical characteristics. This novel approach to a packaging problem allows the use of economical, standard size substrate material.



4. The finished product demonstrates the uncluttered layout that this design process leads to. Note how line widths determine the impedance of each section. The 6.6W amplifier offers excellent heat distribution.

point D in Fig. 1d. Point D is rotated toward the load until the real axis of the Smith chart is intercepted at point D′. The final value after normalizing is 55 ohms. Eq. 2 determines the characteristic impedance of the quarter-wave line needed to transform 55 ohms to 50 ohms. The required impedance of the line is 52.5 ohms.

Proof of the pudding

Proof of the systems approach comes when power is applied to the amplifier. A bit of trimming is needed on the microstrip lines to obtain the maximum gain. Starting with the input, this is done by discretely applying indium foil at selected locations on the microstrip line, until the gain is optimized. Touching the microstrip lines with the small metallic end of a tuning wand will generally give a clue as to where and how much indium must be added. Visual indicators, such as a power meter attached to the output and current meters in the dc supply lines, may be used for peaking.

The results are good enough to make this effort worthwhile. With a driving power of 400 mW, this amplifier belts out 6.6 W at 2.3 GHz corresponding to 13 dB gain. Efficiencies of the driver and power amplifier stages are 32% and 34%, respectively. The amplifier is very stable with no tendency to oscillate. Reducing the drive level causes the output power to fall off at a linear rate commensurate with the input.

The use of a three-section transformer in the interstage produces some unexpected results. A somewhat wider bandwidth than that obtainable with a single section transformer is observed. Also, the three-section transformer enhances the stability of the amplifier because it gives a better match over a wider frequency range. Replacing the transistor with other ones of the same type will cause small changes in the output power, but not enough to warrant touching up the circuitry. This is a desirable feature because it eliminates the need for variable tuning capacitors. After all, fewer parts mean less cost and higher reliability. ••

1. Lieberman, N., "New 2.5 Watt 4 GHz Fundamental Source", *Microwave Systems News*, Vol. 2, No. 13, pp. 51-52 (Oct/Nov., 1972).
2. Moore, R. K., *Traveling-Wave Engineering*, McGraw-Hill, New York, p. 270 (1960).
3. Schilling, W., "The Real World of Micromic Substrates-Part 3", *MicroWaves*, Vol. 8, No. 3, pp. 57-59 (March, 1969).
4. Womack, C. P., "The Use Of Exponential Transmission Line In Microwave Components," *IRE Transactions On Microwave Theory and Techniques*, Vol. MIT 10, No. 3, pp. 124-132, (March, 1962).

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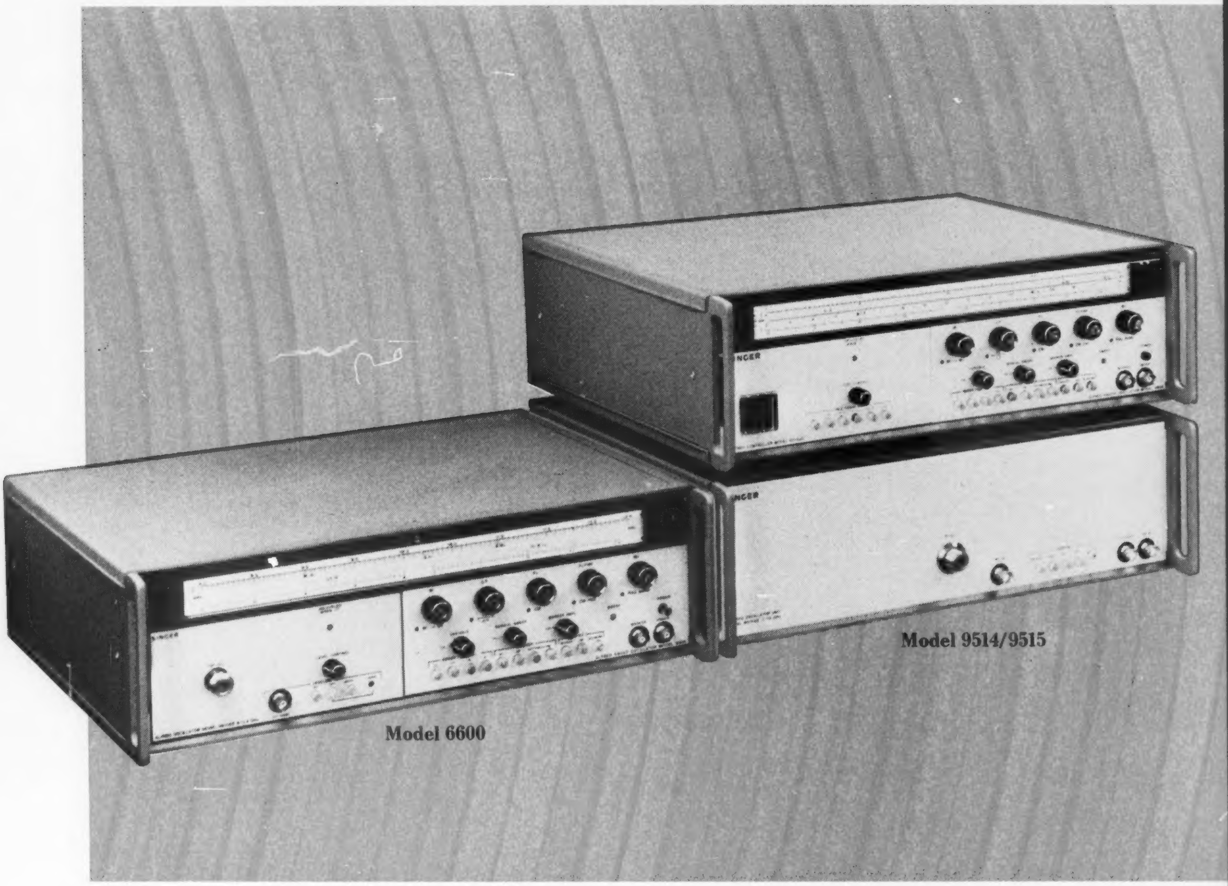
Singer sweeps



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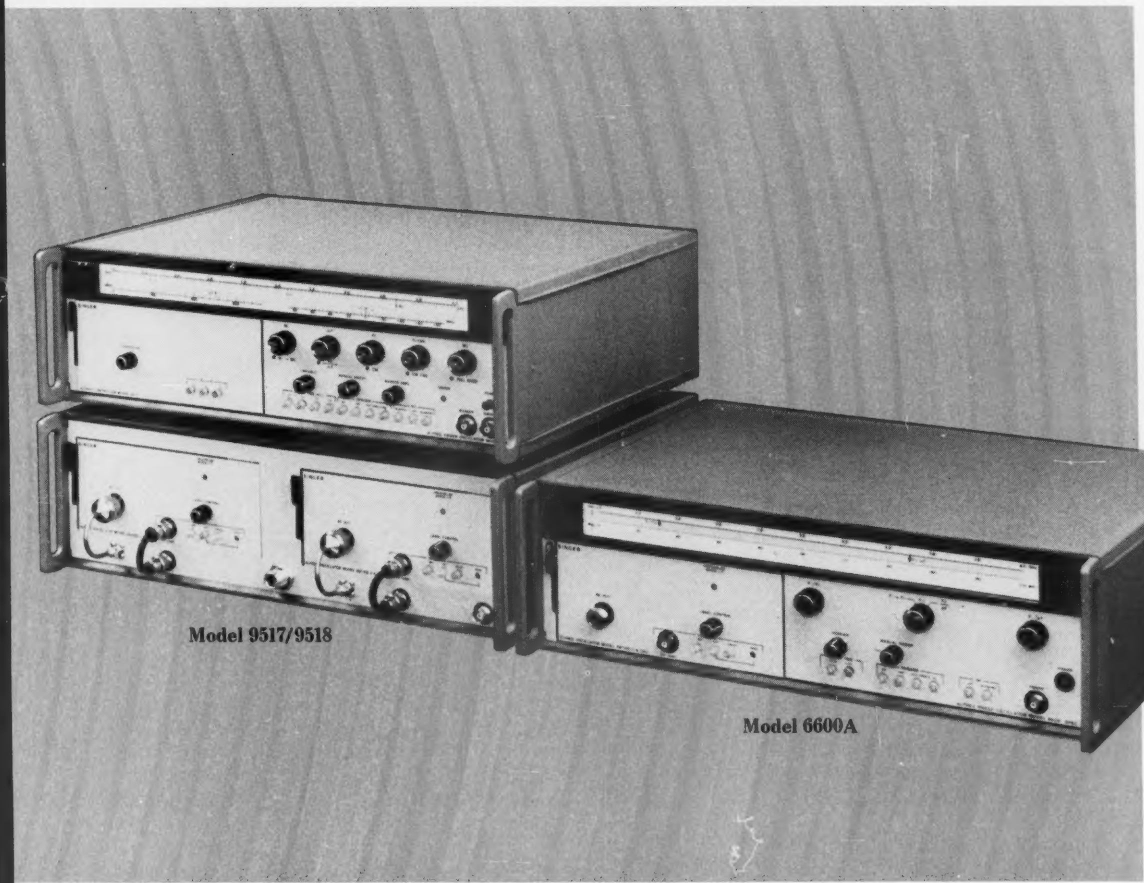

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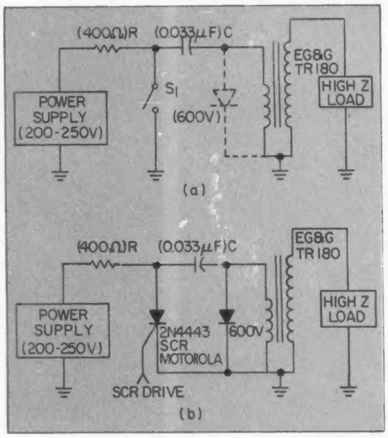
Simple Circuit Triggers Lasers

Triggering a laser need not be complicated. Here is a simple trigger circuit applicable wherever high rep rate, high-voltage pulses are required.

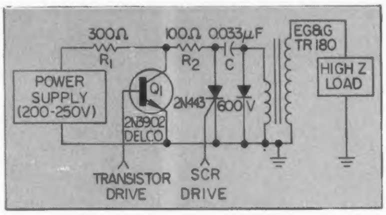
Designers often need high-voltage waveforms at high repetition rates, such as for laser triggering. The "trick" is to select combinations of devices and techniques to yield the desired performance. Here is a combination of devices that can be used to generate a 4 kV laser triggering waveform at a repetition rate between 10 and 12 kHz. To generate the high-voltage pulse, required to ignite a gas laser, a capacitor can be discharged through a transformer primary circuit, Fig. 1. Basically, the circuit consists of a step-up transformer and an R-C charging network. If capacitor C is fully charged, the closing of Switch S_1 (at *a*) will impress a voltage step across the L-C network and will produce a damped sinusoid at the transformer primary. How quickly the capacitor is charged is determined by the magnitude of resistor R, in combination with the transformer primary impedance and the current capability of the power supply. More rapid charging of the capacitor can be obtained by adding a diode of the proper rating across the transformer primary, as shown.

The substitution of an SCR for switch S_1, Fig. 1 *b*, allows the necsary voltage step to be applied to the L-C circuit. A tradeoff occurs at this point, because to obtain a high repetition rate, R must have the lowest possible value. Yet, if R is too small, the current through the SCR will be greater than its holding current and will not turn off. Consequently, with this circuit, the repetition rate is directly proportional to the holding current of the SCR. To avoid this limitation, it was desired to obtain a device that would allow the SCR

Oscar Jensen, Consultant
208 Foster Drive, Willimantic, Conn.



1. **The laser triggering circuit** (a) is the basis for developing high-voltage, high repetition-rate triggers. The switch is replaced by the SCR in (b). The rep-rate is dependent on the SCR holding circuit.



2. **To overcome the basic circuit limitation** of rep rate dependence on holding current, Q_1 was added, along with isolation resistor R_2. This, then, is the final working circuit design.

to be "starved" of current after it has been turned on for the desired time. Thus, a transistor was placed in parallel with the SCR, Fig. 2. To provide isolation, so that the transistor collector is biased properly in its "off" condition and to limit transistor collector current to a safe value, R is split into two separate resistors, R_1 and R_2. R_2 provides for the necessary isolation and a positive voltage at the transistor's collector when the SCR is "on". R_1 must be of sufficient magnitude to limit the collector current to a safe value. R_1 and R_2 together, serve the purpose of the R in Fig. 1 to establish the desired charging rate.

Sequence of operation

Here's what happens: The SCR is turned on and a voltage step is applied to the L-C combination. After an appropriate time delay, the transistor is turned on so that the SCR is "starved" of its holding current and will return to its "off" state. The transistor turns off, thus allowing the sequence to begin again.

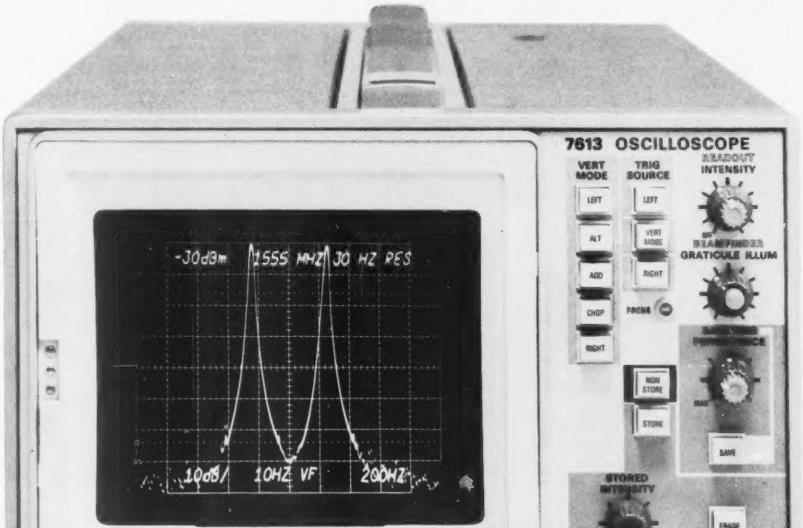
The relevant tradeoffs are clearly observed by graphical interpretation of circuit requirements and limitations. The first step is selection of C. The appropriate graph for this, Fig. 3, presents open circuit transformer voltage vs. available power supply voltage with capacitance as the running parameter. The transformer output voltage into an open circuit may be expressed as e=L di/dt, where L is the inductance of the transformer. The current available from the capacitor is $i=C\, dV/dt$, where V is the available power supply voltage. Substituting, $e=LC\, d^2V/dt^2$. If the capacitor is assumed to discharge in a normal manner, d^2V/dt^2 may be interpreted as a circuit constant proportional to available supply voltage V. Thus, $e=KLC$, where K and L are known.

The second step is to consider R_1 and R_2 tradeoffs. Note that $R=V_{max}/I_{max}$ where V_{max} and I_{max} are the maximum available power supply voltage and current, respectively. $R_1=V_{max}/I_c$ where I_c is the allowable collector current. $R_2= V_{bias}/I_h$ where V_{bias} is the desired biasing voltage for transistor Q_1 when the SCR is "on" and

(continued on p. 56)

the 30Hz Resolution Revolution

Spectrum Analysis in the 0-to-1800 MHz region



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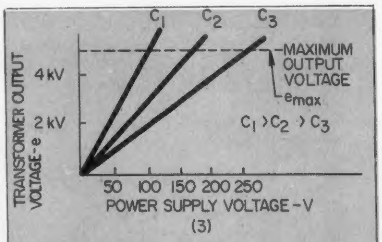
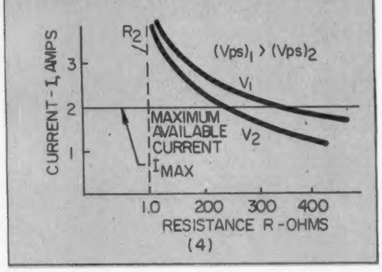




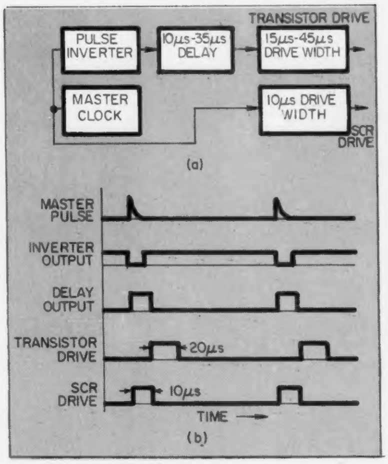
3. **Output voltage,** e, varies with supply voltage and with capacitance, as shown.

4. **Charging resistance and supply voltage are interdependent** as indicated here. R_2 is fixed by the SCR used; thus R_1 must be selected according to the total R required to meet capacitor charging time.

I_h is the SCR holding current. Thus, $V_{max}/I_{max} = V_{max}/I_C + V_{bias}/I_h$, or $R = R_1 + R_2$. In Fig. 4, which plots current vs. resistance for two values of power supply voltage, R_2 is fixed based on required SCR bias; thus, R_1 is a function of the available power supply voltage and current.

Driving the pulse generator

Driving signals must be supplied to the SCR and transistor, Fig. 5. Typical waveforms, shown, give the relationships between signals from the various stages. Because the SCR needs at least a 5 μs pulse to drive it properly, a pulse width of 10 μs was chosen to minimize firing problems. A pulse width of 20 μs was found satisfactory for driving the transistor. It is important that the transistor fire after the SCR has been turned on. This is assured by using simple logic circuitry to produce an appropriate delay and proper driving pulse width. ••



5. **The suggested drive circuit** consists of a master clock plus wave-shaping and delay circuits. The block diagram (a) is a good example. Waveforms produced in the driver are shown at (b).

Bibliography

1. O. W. Jensen, "Laser Spectrum Modulation—As Applied To A Pulsed Laser Communication System," Masters Thesis, UCLA Dept. of Electrical Engineering, (1969).
2. "SCR Manual-Fourth Edition," General Electric Co., Syracuse, NY, (1967).
3. "Switching Transistor Handbook-First Edition," Motorola, Inc., Phoenix, AZ (1963).

Correction to Microwave Notebook

To The Editor:

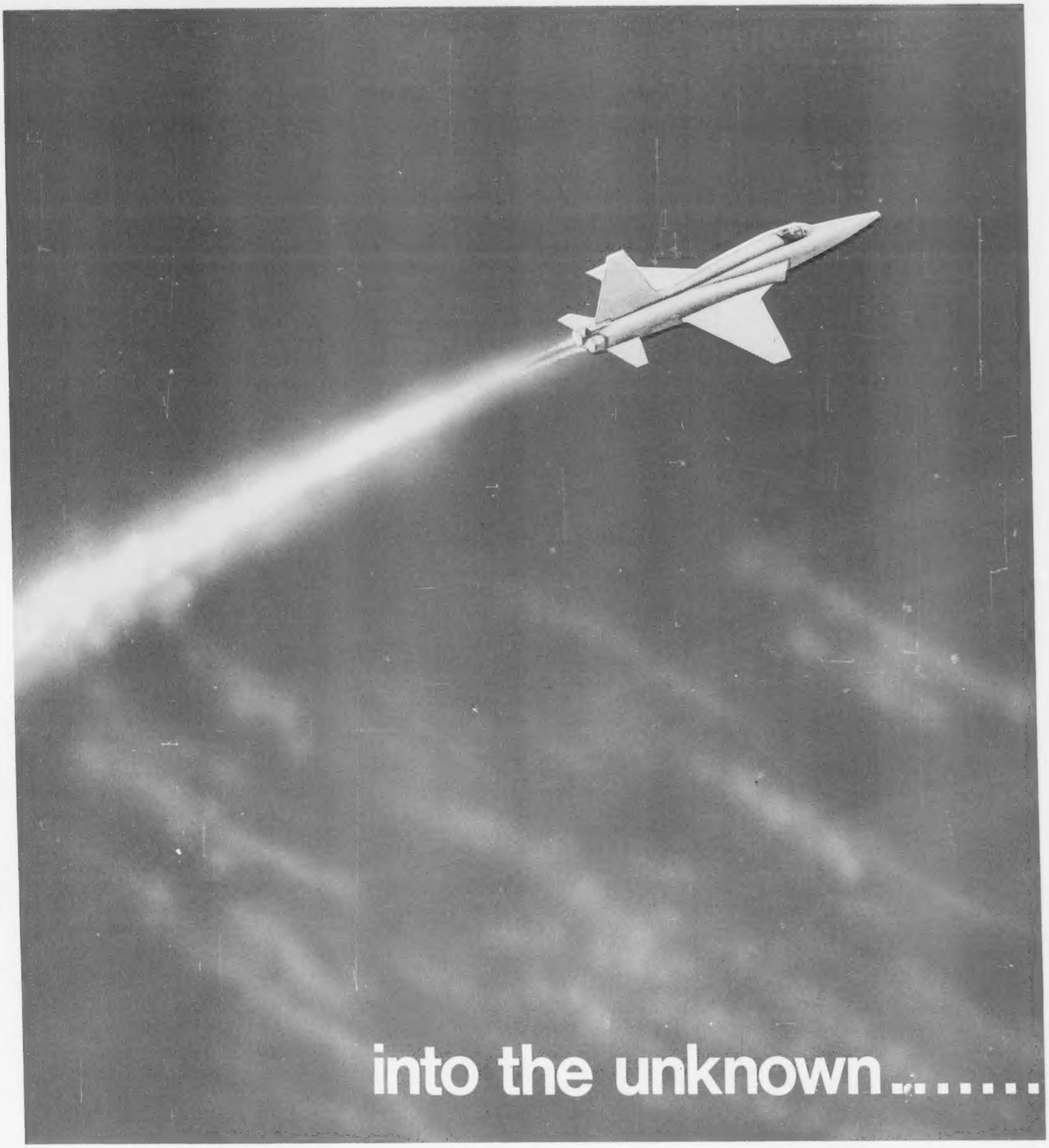
In "Measure Fm With High Modulation Index Three Ways", (Oct., '73 p. 85), the equation describing the frequency difference between observed peaks was incorrectly stated. It should read:

$$\beta = \frac{\Delta F_p}{2 f_m} + 0.9316 \left(\frac{\Delta F_p}{2 f_m}\right)^{0.3048}$$

where f_m = modulating frequency.

In response to an inquiry I've had on this item, I've prepared a note which gives a derivation of this equation. I'd be prepared to supply copies of this note to anyone who would contact me.

Emanuel Kramer
ESL, Inc.
1701 North Fort Meyer Drive
Suite 711
Arlington, VA 22209.


into the unknown........

application notes

Take a new look at an old idea

Today's trend toward automated measuring techniques is precipitating a re-evaluation of the power equation concept for uhf and microwave measurements. A National Bureau of Standards publication, "Theory of UHF and Microwave Measurements Using The Power Equation Concept," reassesses the idea in light of the extensive phase data that can be generated by automated measuring systems.

In the past, the power equation concept has largely been avoided because of the difficulty associated with making the required phase measurements. A variety of tuning procedures evolved to eliminate the need for extensive phase information. Unfortunately, these tuning procedures are usually frequency sensitive and detract from the measurement's accuracy. Now that phase information is readily available from automated measurement systems, the tuning schemes can be eliminated.

Glen F. Engen, the author of this 68-page technical note, cites independence from uniform waveguide systems, relaxed connector requirements and explicit accounting for mismatch errors as reasons to consider the power equation concept. SD catalog No. C13.46:637 is $.70 a copy. Microfiche copies are $.90 apiece. **U. S. Government Printing Office, Washington, DC 20402.**

READER SERVICE NO. 219

Probing in perspective

Almost any oscilloscope and probe combination can be used to view a waveform. However, since all probes inherently introduce some degree of error, it is important to select a probe that reduces the error to an acceptable or known level. "Probing In Perspective," a 12-page application note by Vic Bunze, explains:

- How to select the most accurate scope/probe combination for a particular measurement.
- How to estimate errors caused by the probe.
- How to quickly evaluate a given scope/probe for its adequacy in any situation.

Voltage probes may be grouped into three classes. High-resistance probes, miniature passive-divider probes and active probes each have unique capabilities and limitations largely determined by their resistive and capacitive circuit loading effects. High-resistance probes, for example, present a high-input impedance at dc but are unsuitable for high-frequency measurements because of high-shunt capacitance loading. The author presents plots of loading effects as a function of frequency for many combinations of R-C probes that are useful references for making quick evaluations of loading errors. Ask for application note 152. **Hewlett-Packard Company, Colorado Springs Division, 1900 Garden Of The Gods Road, Colorado Springs, CO. 80907.**

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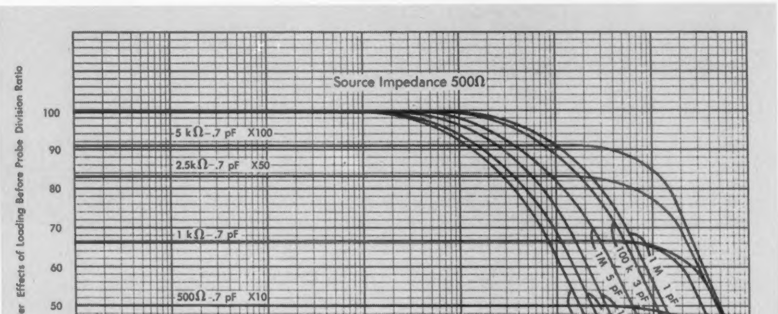

1. **Errors in cw amplitude** measurements caused by the loading effect of test probes can be estimated from this chart.

microwave notebook

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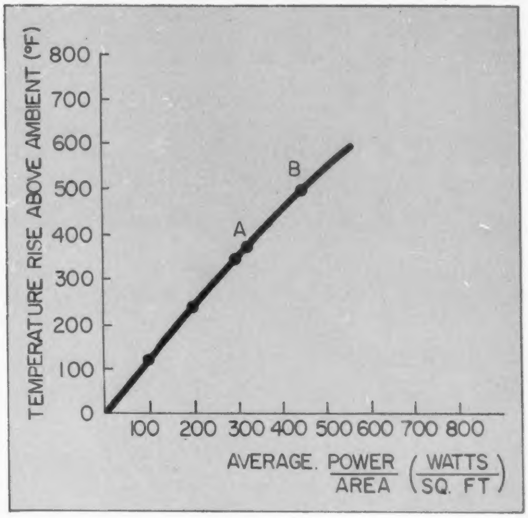
Calculate temperature rise quickly under high-power testing

When running a high power microwave test circuit questions may arise concerning the temperature rise above ambient that can be expected on the surface of the rf loads. The graph shown is a useful reference from which the temperature rise on a waveguide termination may be read directly after simply dividing the input power by the exterior surface area of the loads (watts/square foot). The values shown are based on still air. The curve is not valid when forced air or liquid cooling is used since these conditions introduce several variables.

The points on the curve represent tests made at X, C and S bands (WR90, WR187 and WR284). Essentially, the curve is independent of frequency and waveguide size.

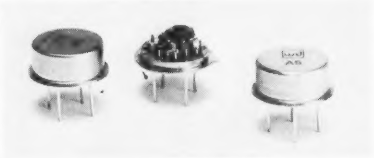
It should be noted that since load materials can withstand higher temperatures than the adhesive used to cement them into the waveguide, the limiting power factor will be the adhesives used. In general, adhesives soften at 300° to 400°F and completely fail at 500°F. If the calculated ambient plus temperature rise exceeds 400°W it is suggested that either the load be cooled or the surface area of the load be increased or both—to reduce the temperature.

J. Ciavolella, Senior Engineer, Westinghouse Electric Corporation, Friendship International Airport, Box 746, Baltimore, MD 21203



Vote, Circle READER SERVICE NO. 216

Miniature 5-500 MHz unit amplifiers deliver up to 20 mW with 13 dB gain



1. **Unit amplifiers,** models WJ-A5 and -A7, can be directly inserted into 50 Ω microstrip circuits in either wideband or narrowband and i-f applications. They are housed in hermetic four pin TO-8 packages. Both amplifiers are designed to MIL-E-5400, Class 2 and MIL-E-16400, Class 1.

Integrated thin-film amplifiers, models WJ-A5 and -A7, are now available from Watkins-Johnson with guaranteed performance over a −54° to +100°C or −54° to +71°C temperature range, respectively. Both units have a minimum small signal gain of 13 dB and gain flatness of ±0.7 dB over the

Table of Specifications

Characteristics	WJ-A5 @ 15V	WJ-A7 @ 24V
Gain flatness, max (5-500 MHz)	±0.7 dB	±0.7 dB
Small signal gain, min (5-500 MHz)	13 dB	13 dB
Noise figure, max (5-200 MHz)	5.5 dB	6.5 dB
Noise figure, max (200-500 MHz)	6.0 dB	7.0 dB
VSWR in/out, max (10-200 MHz)	1.7:1	1.7:1
VSWR in/out, max (5-500 MHz)	2.0:1	2.0:1
Power output, min	+7 dBm	+12.5 dBm
Intercept Pt., typ	+22 dBm	+26 dBm
Reverse isolation, typ	20 dB	20 dB
Dc current, typ	25mA	42mA
Weight	1.85 grams	1.85 grams

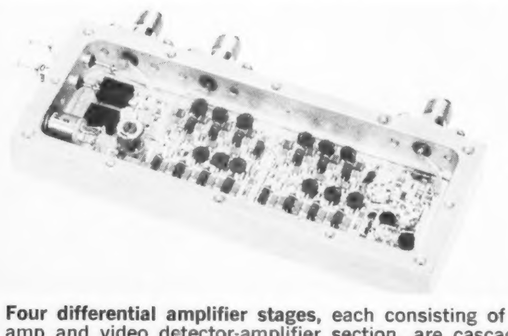
Wideband log amplifiers handle 10 ns pulses over 60 dB dynamic range

Log amplifiers, series ICLT, cover the uhf band from 300 MHz to 1 GHz and provide a dynamic range of 60 dB with a −65 dBm to −5 dBm input. Standard units are optimized at the center frequencies shown in the table and can faithfully reproduce pulse rise times of under 10 ns without ringing or overshoot. Frequency agile units, series ICLT (suffix A), are optimized over the entire operating bandwidth for either cw or pulsed signals. Linearity with a 1.25V output (into 93 Ω) is ±1 to ±2 dB and is relatively independent of frequency. Over a 0°C to +50°C temperature range linearity degrades an additional ±1 dB and from −30°C to +71°C an additional ±1.5 dB.

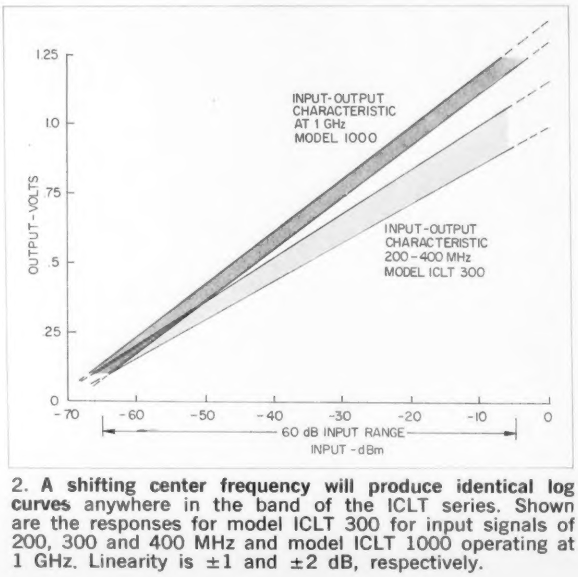
Slope changes for the log curves anywhere inband is ±5% at constant temperature (±10% for ICLT1000) and 15% over a 0° to +50°C temperature range. Over the extended temperature of −30°C to +71°C, slope change is ±17.5%. P&A: $1100 to $1400, frequency agile units cost an additional $250; 60 days. **RHG Electronics Laboratory, Inc., 161 E. Industry Court, Deer Park, NY 11729 (516) 242-1100.**

READER SERVICE NO. 104

Model	Center Frequency (MHz)	Operating BW (MHz)	Linearity (dB)
ICLT300	300	200-400	±1
ICLT475	475	400-550	±1.5
ICLT625	625	550-700	±1.5
ICLT775	775	700-850	±2
ICLT925	925	850-1000	±2
ICLT1000	1000	950-1050	±2



1. **Four differential amplifier stages,** each consisting of an i-f amp and video detector-amplifier section, are cascaded onto a single alumina substrate. Multiple substrates are then combined to form the complete amplifier.



2. **A shifting center frequency will produce identical log curves** anywhere in the band of the ICLT series. Shown are the responses for model ICLT 300 for input signals of 200, 300 and 400 MHz and model ICLT 1000 operating at 1 GHz. Linearity is ±1 and ±2 dB, respectively.

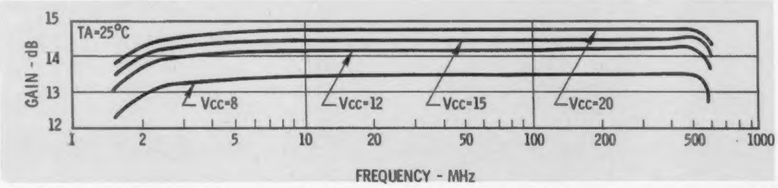
entire band of 5 to 500 MHz. Power output for WJ-A5 is +7 dBm and for WJ-A7 is 12.5 dBm, minimum.

Each unit amplifier is unconditionally stable for any source or load condition. Up to four stages may be cascaded in a common box without rf shielding between each unit. The total cascaded gain is approximately 58 dB and gain flatness is typically ±0.5 dB or better across the 5-500 MHz band. There is no bandwidth shrinkage or loss of maximum output power with cascaded units.

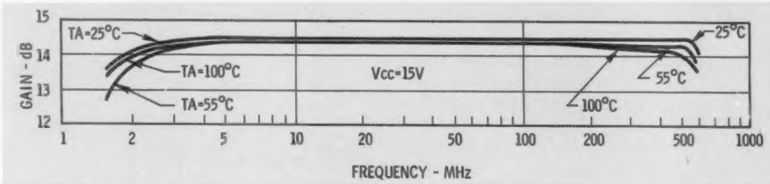
To meet specifications over temperatures, a very stable dc biasing circuit is used along with low temperature coefficient thin-film tantalum nitride resistors. The resistors are designed to operate under relatively low power densities to insure long operating life with minimum drift. High temperature heat treating is performed on each thin-film resistor to yield long-term stability. A thin-film inductor is used in the output matching section and use of a microwave transistor with a very high f_T provides very repeatable phase and gain characteristics across the band. Typical phase linearity is within ±2.5° from 10 to 500 MHz.

The WJ-A5 operates over a power supply voltage range of 8-20 Volts. Specifications are given at 8, 12, 15 and 20 Volts. P&A: In qtys of 100, WJ-A5, $77; WJ-A7, $84; stock to 30 days. **Watkins-Johnson Company, 3333 Hillview Avenue, Palo Alto, CA 94304 (415) 493-4141.**

READER SERVICE NO. 154



2. **Gain performance** for the WJ-A5 is relatively unaffected over a 55° to 100°C temperature variation.



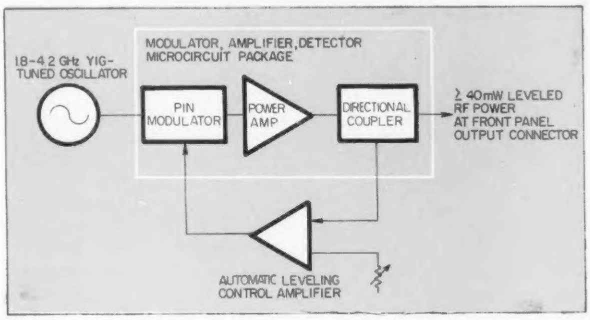
3. **The W-J-A5 operates over 8 to 20V** power supply voltage range. Small signal gain is typically 14.5 dB over the entire band.

Sweeper modules deliver over 16 dBm

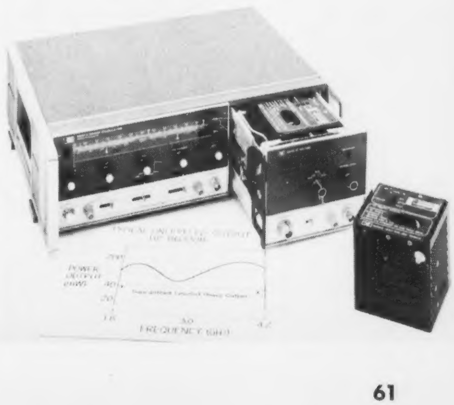
For high-power sweeper applications at S-band, Hewlett-Packard introduces two new power modules that fit into the rf drawer of their 8620 (A or B) main frame solid-state sweeper. Model 86330B has 40 mW of leveled rf power from 1.8 to 4.2 GHz. Model 86331B provides over 20 mW leveled or 100 mW of unleveled power from 1.7 to 4.3 GHz. Leveled power variations are ±0.7 dB and ±0.8 dB, respectively and ±4 dB and ±5 dB for unleveled applications. Frequency accuracy for all sweep times over 100 ms is ±20 MHz and ±25 MHz, respectively. Frequency stability with temperature is ±500 kHz/°C and with a 3:1 VSWR load variation (all phases) is ±1 MHz. Residual fm in 10 kHz BW (in cw mode) is under 7 kHz peak.

The PIN modulator used for leveling is a combination of series and shunt PIN diodes designed to allow 40 dB of power level control. The amplifier consists of two stages with two transistors in parallel in each stage. HP 35820 series transistors are used with an f_{max} of 12 GHz. Linear gain of 10 dB is achieved over the frequency range of 1.7 to 4.3 GHz with typical output power of 100 mW. When internal leveling is needed, a directional detector in a balanced stripline configuration can be added. These components are fabricated using hybrid thin-film techniques on sapphire substrates. P&A: model 86330B is $2,050, model 86331B is $2,300, for internal leveling add $250. Main frame 8620B is $1,025, 8620A is $1,500, drawer 8621B is $425. **Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304 (415) 493-1501.**

READER SERVICE NUMBER 103



These components are integrated into a single hybrid thin-film package to minimize losses and reduce mismatch.



new products

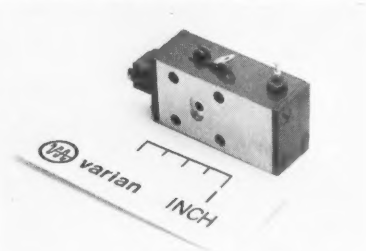
OSCILLATORS

Current regulator for Impatt oscillators

Regulator module (models 140/141) regulate the current required for Impatt diodes and can be installed in series with the Impatt diode. These two-terminal modules feature 8 to 140 V operation and characteristics enhanced by inherent noise rejection and short circuit protection. Regulation is 0.05% and temperature stability is 0.3%. The current range of 10 through 200 milliamperes is covered by two adjustable models, one of 1.5 W and one of 5 W. P&A: $48, $68, respectively; stock to 3 wks. **Electronic Modules, Inc., 2500 East Foothill Blvd., Pasadena, CA 91107 (213) 795-4231.**

READER SERVICE NO. 118

Gunn oscillators cover 26.5-42.0 GHz



Gunn-effect oscillators, series VSA-9010, deliver cw output power ranging from 5 to 150 mW. Standard models are tunable ±100 MHz from any specified frequency between 26.5 to 42.0 GHz. Upon request, special versions can be furnished either fixed, tuned or with a tunability of ±350 MHz or more.

Bias voltage is typically 4.5 Vdc. Max bias voltage up to 32 GHz max is 7.0 Vdc while max bias voltage above 32 GHz is 6.0 Vdc. Power/temperature coefficient is ±0.04 dB/°C max while power supply regulation is 0.01% max. Load VSWR is 1.2:1 max. **Varian, Solid State West Division, 611 Hansen Way, Palo Alta, CA 94303 (415) 493-4000.**

READER SERVICE NO. 115

BVT sources cover C and X-bands

Biased voltage tuned cw oscillators are offered in six new models.

Model CA600C covers 4 to 8 GHz and features 100 to 300 mW output with ±250 MHz tuning. Model CA650C covers 4 to 8 GHz and has an output ranging from 20 to 100 mW with ±500 MHz tuning. For higher powers, model CA500C tunes ±100 MHz and provides 400 mW in C-band while model CA550X, tuning over the same range, gives 200 mW for X-band applications. Other new models, CA700C and CA-750X cover 4 to 8 GHz and 8 to 12 GHz, respectively, and are ideal for LO sources. **Cayuga Associates, Inc., Cornell Research Park, Ithaca, NY 14850 (607) 257-0555.**

READER SERVICE NO. 122

MM wave BWO deliver +6 dBm, 33 to 50 GHz

Magnetically shielded helix structure BWO, WJ-2055, delivers +6 dBm min power output from 33 to 50 GHz. Tuning voltage is less than 2,000 V and the beam current is 6 mA max. Size is 4 in. x 4 in. x 8 in. and weight is 6.5 lbs. **Watkins-Johnson Company, 3333 Hillview Avenue, Palo Alto, CA 94304 (415) 493-4141.**

READER SERVICE NO. 120

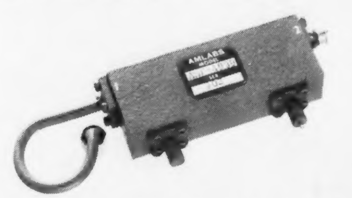
Pulsed sources tunable ±200 MHz

Pulsed Gunn signal source, model CA 400-OM, has center frequencies from 4 to 12 GHz, tunable ±200 MHz. With min output power of 125 mV, the source exhibits a VSWR of less than 1.25. Pulse width can be varied from 0.1 to 1.0 μs and the prf is 5 kHz. The unit requires a 28 Vdc, 500 mA power source and accepts 5 V logic inputs. OSM female connectors are standard. P&A: typically $975; 60 days. **Cayuga Associates, Inc., Cornell Research Park, Ithaca, NY 14850 (607) 257-0550.**

READER SERVICE NO. 127

SWITCHES

Modulators have PIN-diode switching

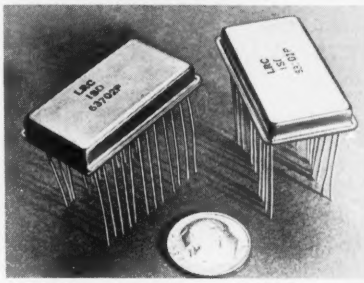


These Iso-Modulators provide amplitude modulation and feature a PIN-diode switch module with isolators on both input and output. All models have an output to input isolation of 35 dB, max VSWR of 1.6 and handle 100 mW. Min insertion loss with a 20 mA bias is 40 dB.

Model AIM-2040 covers 2 to 4 GHz and has a max insertion loss of 1.8 dB with 0 mA bias; model AIM-4080 covers 4 to 8 GHz with 1.8 dB loss; model AIM-8012 covers 8-12.4 GHz with 2.0 dB loss; model AIM-1218 covers 12-18 GHz with 2.6 dB loss. P&A: $425. **Aertech Industries, 825 Stewart Drive, Sunnyvale, CA 94086 (408) 732-0880.**

READER SERVICE NO. 124

Six switches and drivers in a single package



Series of integrated switches and drivers are designed to provide rf control from 10 to 200 MHz. Up to six separate switches and drivers are housed in a single 24 pin DIP package. Isolation ranges from 30 dB to 50 dB min, and insertion loss is from 1.5 dB to 2.2 dB max depending on which of the three models is selected. No bias connections or dc blocks are required in the rf line. Driver inputs are TTL compatible with built-in fail-safe provisions. If the input gate level is open circuited, the switch goes to an isolation state. Power supply requirements are +5 V. All units are available with MIL-STD-883 screening. **LRC, Inc., 11 Hazelwood Road, Hudson, NH 03051 (603) 883-8001.**

READER SERVICE NO. 107

JOIN The Antennas And Propagation Society

We invite you to become a member of the IEEE Antennas and Propagation Society (formerly, the Group on Antennas and Propagation) in this, its twenty-fifth year since founding.

Devoted to the furtherance of research, development and engineering in antennas, propagation, scattering, and electromagnetic theory, the Society joins together 4000 colleagues interested in the above disciplines. It offers to its members bi-monthly Transactions, recognized throughout the world as the leading publication in the field and sponsors conferences which annually call together engineers and scientists working in the electromagnetics discipline to report their recent accomplishments. The Society sponsors an Outstanding Lecturer series, bringing to its local chapters distinguished men to discuss their areas of expertise. Through its technical and administrative committees, the Society offers a forum from which to speak to the profession and about the profession on all matters of interest to its members.

If you are not yet a member of the Antennas and Propagation Society, we invite you to fill out and send the accompanying application form to:

Dr. R. J. Garbacz, Memb. Chairman
ElectroScience Laboratory
The Ohio State University
1320 Kinnear Rd.
Columbus, Ohio 43212

NAME ____________________

Mailing Address: ____________________

____

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Affiliation: ____________________

Field of interest: ____________________

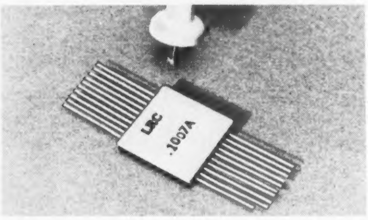
☐ **I am a** __________ **member** (give grade) **of IEEE** and hereby apply for membership in the Antennas and Propagation Society. Enclosed is a check for the Society fee.
Annual Rates: $8.00
(Make checks payable to IEEE)

☐ **I am not a member of the IEEE.** Please send me more information.

READER SERVICE NUMBER 65

SWITCHES

10ns driver for series/shunt switches

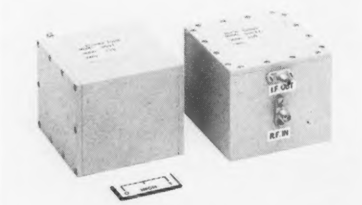


High-speed rf switch driver, model SD-1007A, provides current from either positive or negative supply voltage (±12 V) (depending on input from a TTL gate) and has a total switching time of 10 nanoseconds (max) with typical delay and rise time of less than 5 nanoseconds. It is compatible with both TTL and DTL circuits and can drive shunt, series and series-shunt switches. A pull-up circuit, built into the input allows dc testing. Fail-safe design provides for the switch driver to be at logic "0" when the gate is short circuited and at logic "1" when it is open circuited. MIL-STD-883 screening is available. **LRC, Inc., 11 Hazelwood Road, Hudson, NH 03051 (603) 883-8001.**

READER SERVICE NO. 105

SYSTEMS

Complete front ends measure 2" × 2.5" × 2.5"



Electronically-tuned receiver front ends, VZ-3001 series, include a preselector YIG filter, a YIG-tuned transistor local oscillator which tracks the filter-center frequency, a balanced mixer and a low-noise i-f preamplifier all combined in a small, lightweight package. Models VZP-3001, VZL-3001 and VZS-3001 cover 0.5-1.0 GHz, 1.0-2.0 GHz and 2.0-4.0 GHz, respectively. Noise figure is 15 dB max for all models. I-f gain is 25 dB, and 3 dB bandwidth is 20-30 MHz. LO radiation is −80 dBm and input power is 6 to 10 W. **Varian, Solid State West Division, 611 Hansen Way, Palo Alto, CA 94303 (415) 493-4000.**

READER SERVICE NO. 116

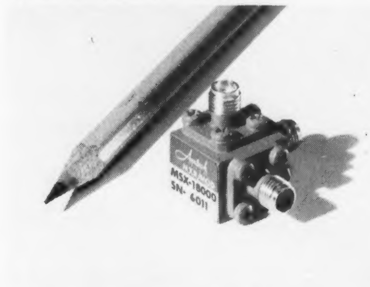
Comm. downconverter offers 40 dB gain

Communications downconverter, model AM 3742-LN, covers 3.7-4.2 GHz. I-f frequency is 50-90 MHz over the −0.2 dB points. Conversions are available in either single or dual. Noise figure is 10 dB (4.5 dB with low-noise preamplifier), and frequency stability is 0.0005%. **Miteq, Inc., 100 Ricefield Lane, Hauppauge, NY 11787 (516) 543-8873.**

READER SERVICE NO. 113

MIXERS

Mixers need only +5 dBm LO drive



Single-balanced mixers in the MSX series cover 2 to 18 GHz in nine models. SMA connectors are standard on these two-diode devices. Typical specifications are 25 dB min isolation, 5 dBm LO power and 7.5 dB max conversion loss. Although coaxial connectors are standard, waveguide flanges are available on models covering 6 to 11, 8 to 12.4, 10 to 15 and 8 to 16 GHz ranges. P&A: $160 to $450 in qtys 1-4. **Aertech Industries, 825 Stewart Drive, Sunnyvale, CA 94086 (408) 732-0880.**

READER SERICE NO. 123

GaAs mixer diodes offer 5 dB NF

GaAs mixer diodes operating from 6-10 GHz offer guaranteed noise figures from 5 to 7.5 dB in 0.5 dB increments. Two popular package styles are available "MQM" (model SSX-44100) and pill (model SSX-44200). The pill-configured diode is readily usable in both microstrip and stripline applications. Burnout rating is 12 W peak power at 1 ns pulse lengths and min compression point is 5 dBm. Delivery: 2 wks. **Sperry Microwave Systems, Microwave Components, Dept. 9000, Waldo Road, Gainsville, FL 32601 (904) 372-0411.**

READER SERVICE NO. 117

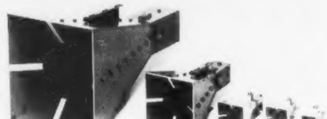
ANTENNAS

Air traffic control array boasts 8 dBi gain

A four bay, vertically polarized, omnidirectional collinear array, the TECOM 401031 is for military (225-400 MHz) air-traffic communications. It has a gain of 8 dBi, an average VSWR of 1.2:1 and handles 2 kW average power. The array is radome enclosed, foam filled and hermetically sealed against rain, salt air, birds and ice and is designed to function reliably in an 85-mph wind with a half-inch of radial ice. The TECOM 401031's beam width is omnidirectional ±3/4 dB in azimuth and is 19° at midband in elevation. The antenna weighs 60 lbs and is 104 in. high and 8 5/8 in. in diameter. **Tecom Industries, Inc., 9000 Ownesmouth Avenue, Canoga Park, CA 91304.**

READER SERVICE NO. 125

Horn antennas cover 1 to 12 GHz



A family of quad-ridged horn antennas, the WJ-8326 Series covers the standard 1 to 2, 2 to 4, 4 to 8, 8 to 12 and 12 to 18 GHz bands. Each pyramidal horn has two orthogonally placed input feeds which provide the capability for horizontal, vertical and (with a 90° hybrid) right or left hand circular polarization. They are also ideally suited for feeding high-gain dishes for ECM, surveillance and direction-finding applications as well as primary radiators. **Watkins-Johnson Company, 3333 Hillview Avenue, Palo Alto, CA 94304 (415) 493-4141.**

READER SERVICE NO. 111

TEST INSTRUMENTS

Module expands range of monitor to 1.3 GHz

This module, model RFM-11A, increases the maximum frequency capability of Singer's FM-10C communication service monitor to 1.3 GHz. It features an input sensitivity adjustable from 20 μV to 20 mV and can be used to service TACAN/DME equipment, air-traffic control radar beacons and the new 900 MHz mobile radios. P&A: $1,295; 8 wks. **Singer Instrumentation, 3211 S. La Cienega Blvd., Los Angeles, CA 90016 (213) 870-2761.**

READER SERVICE NO. 130

Frequency counter meets communications needs

Portable frequency counters, models 6251 and 6252, cover the frequency range to 512 MHz and 180 MHz, respectively. Each has a special multiplier for TONE measurements with resolutions to 0.001 Hz in only one second. A choice of five phased locked local oscillators offering stabilities of ±3 parts in 10^7 month to 5 parts in 10^{10} per day are available.

Input sensitivity of model 6252 is 25 mV rms to 50 MHz and 50 mV rms for inputs above 50 MHz. The input is coupled to a level meter for input monitoring. Full input protection is provided by an overload relay circuit. Measurements are displayed in an eight digit readout and includes leading zero suppression for error-free readings. Optional dc operation is available from an external dc source or from built-in battery pack. P&A: $1,095; 60 days. **Frequency Counter Product Manager, Systron-Donner Corporation, 10 Systron Drive, Concord, CA 94518 (415) 682-6161.**

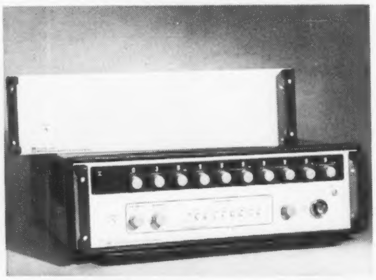
READER SERVICE NO. 102

Pulse transmitter delivers 10 kW at 9 GHz

This short pulse transmitter, model R 200, is designed for high-resolution radar and ECM applications. It can generate 1.0 ns pulses at a frequency of 9.0 GHz and delivers more than 10 kW of peak power. The 58 lb transmitter has a half-power bandwidth of 200 MHz and pulse-repetition rate of 1.0 kHz. Size is 6 x 20 x 21.5 in., power requirements are 115 Vac at 2 A and an SMA output jack is provided. **IKOR, Inc., Second Avenue, Burlington, MA 01803 (617) 272-4400.**

READER SERVICE NO. 128

500-MHz synthesizer has 10 kHz resolution

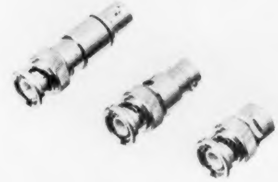


A 500 MHz frequency synthesizer, model GR1062 features residual phase noise of −60 dB which makes it an excellent source to upconvert or multiply into microwave frequency bands. The basic unit provides a leveled output of −7 to +13 dBm into 50-ohms with an 80 dB signal-to-spurious level from 10 kHz to 500 MHz with 10-kHz (five digit) resolution (optional to 0.1 Hz, ten digit). Both frequency and output level can be remotely programmed with a settling time of less than 100 μs. A search-sweep mode provides additional resolution to 100 Hz.

The search-sweep mode allows any decade with 1-MHz steps or less to be varied by continuous control with over-lapping coverage and provides the synthesizer with the convenience of a signal generator for critical resonance or bandpass studies. It also makes possible sweep-frequency measurements because the search-sweep function can be remotely controlled by a sawtooth waveform. Am, fm and pm capabilities are also built-in and controlled by external signals. Model 1062 is supplied without front-panel controls although they are available as options. P&A: from $8,700. **General Radio, 300 Baker Avenue, Concord, MA 01742 (617) 369-4400.**

READER SERVICE NO. 133

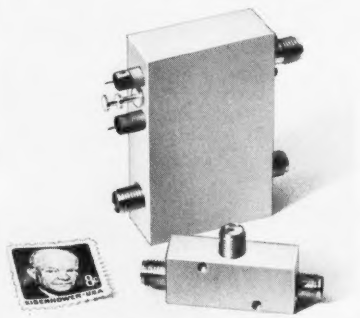
Loads and pads operate dc to 2.5 GHz



This series of uhf coaxial terminations and attenuators covers dc to 2.5 GHz and is supplied with BNC connectors. Model 442 is a coaxial attenuator with fixed attenuation values of 3, 6, 10 or 20 dB. Model 452 is a 50-ohm coaxial termination with a 2 W power rating, while model 454 is a 50-ohm feed-through termination. P&A: models 442 and 454: $20; model 452: $15. **Systron-Donner Corporation, Microwave Division, 14844 Oxnard Street, Van Nuys, CA 94109 (213) 786-1760.**

READER SERVICE NO. 129

Absorptive attenuators cover octave bands



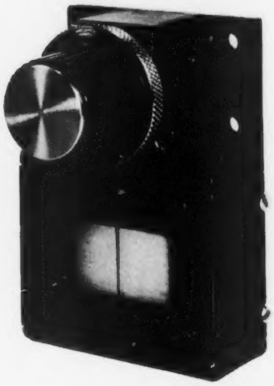
Absorptive attenuators Series CAA-7000, operate over octave bandwidths as shown. Both 40 and 60 dB models are available with or without integral high-speed linearized drivers. Attenuation (dB, max) is 40/60, ±5%, with switching speed 50 nsec. For ECM applications, these devices provide precise pulsing of attenuation levels and continuous, level output minimizing circuit degradation. P&A: 6 wks. **Crown Microwave, Inc., 6 Executive Park Drive, Billerica, MA 01862 (617) 667-4165.**

Performance
40 dB/60 dB

Frequency (GHz)	2-4	4-8	8-16	16-18
Insertion Loss (dB)	1.5/1.8	2.0/2.5	3.5/4.5	3.5/4.5
VSWR (max)	1.7/1.9	1.8/2.0	2.0	2.0

READER SERVICE NO. 106

Portable tape readouts



"Portaread" portable tape readout device, model No. TD 10, features front-loading cover for easy tape access. Each turn of the tuning knob provides 3.5 in. of readout. Zero backlash coupling corrects for device shaft misalignment and quick disconnect spools allow for rapid assembly of tapes. "Portaread" accommodates 0.001 in., 0.002 in. and 0.003 in. thick tapes. Sprockets available for 35 MM, 8 MM and 32 pitch tapes. Standard tape width for this model is 1.165 in.

Tape drive, model TD 30, accommodates 0.001 in., 0.002 in. thick tapes with 32 pitch tape punchings and each turn of tuning knob provides 2.125 in. of readout.

Model TD 20 is designed to give expanded scale direct reading capability to any tunable device. It mounts on a 1/4 in. shaft. Internal stops and shaft locks available. P&A: $53.50; stock. **Direct Reading Controls, Inc., 29 Spring Garden Drive, Madison, NJ 07940 (201) 273-4576.**

READER SERVICE NO. 365

Remote attenuator has 0-20 dB range

This remotely-controlled coaxial attenuator has an attenuation range of 0-20 dB over 5.9 to 6.5 GHz with a VSWR of 1.25. The insertion loss is 0.5 dB max. The electro-mechanical device requires a 115 V ac 50 or 60 cycle single phase source and draws 100 mA. Stopping accuracy is ±0.1 dB. **Waveline, Inc., P. O. Box 718, West Caldwell, NJ 07006 (201) 226-9100.**

READER SERVICE NO. 134

Filter kits feature five cutoff frequencies

These low pass and high pass coaxial filter kits feature five cutoff frequencies ranging from 100 MHz to 12.4 GHz. The kits include: model F-10-K1 minature low pass with 100 MHz, 200 MHz, 400 MHz, 800 MHz and 1000 MHz cutoff frequencies. Model F-30-K1 precision low pass with 1 GHz, 2 GHz, 4 GHz, 8 GHz and 12.4 GHz cutoff frequencies and model F-40-K1 precision high pass with 1 GHz, 2 GHz, 4 GHz, 8 GHz and 10 GHz cutoff frequencies. All filters are bilateral 50-ohm devices available with precision stainless-steel type N or SMA connectors. P&A: $425 and up; stock. **R L C Electronics, Inc., 83 Radio Circle, Mt. Kisco, NY 10549 (914) 241-1334.**

READER SERVICE NO. 132

K-band isolators weigh only 12 oz.

A new series of waveguide isolators cover 18 to 26.5 GHz with five models. Weighing only 12 oz, these devices handle 5-W average power, 5-kW peak. Model K884L1 spans 18.0 to 26.5 GHz and features isolation of 25 dB min, insertion loss of 1 dB max, bilateral VSWR of 1.20 max and is 4.5 in. long. Other models in this series cover 18 to 20, 20 to 22, 22 to 24.5 and 24.5 to 26.5 GHz ranges and feature 30 dB min isolation, 0.6 dB max insertion loss, 1.10 max bilateral VSWR and measures 3 in. All models feature UG-595/U flanges to fit RG-53/U waveguide. P&A: model K884L1: $355; other models: $290; 3-4 wks. **E & M Laboratories, 5388 Sterling Center Drive, Westlake Village, CA 91361 (213) 889-1470.**

READER SERVICE NO. 131

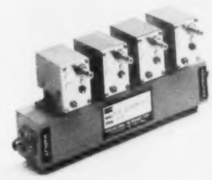
Ku-band isolators have only 0.3dB loss

These waveguide isolators cover the 12.4-18.0 GHz range. Specifications over a 500 MHz BW include isolation of 30 dB min and insertion loss of 0.3 dB max and VSWR of 1.15 max. P&A: $250 ea. in qtys 1-5; 4-6 wks, ARO. **E & M Laboratories, 5388 Sterling Center Drive, Westlake Village, CA 91361 (213) 889-1470.**

READER SERVICE NO. 112

AMPLIFIERS

Log TDA's offer output level control



Tunnel diode amplifiers, series LG-8, cover 4 to 8 GHz, 6 to 10 GHz, 8 to 12 GHz and 12 to 18 GHz bands. Noise figures range from 5.0 to 6.5 dB. The operating temperature is −55 to +71°C. Input VSWR is 1.2:1. All units are instantaneous level controlled with feedback loops, which compress a 65 dB variation of input power into a 10 dB monotonically changing output power. The input/output curve is nearly logarithmic with an adjustable slope compression between 6 and 15. Response time of the feedback loop is 150 ns. Hard limiting TDA's are also available which hold output levels constant to within 0.5 dB while input levels range from −45 to +15 dBm. **International Microwave Corporation, 33 River Road, Cos Cob, CT 06807 (203) 661-5924.**

READER SERVICE NO. 110

Pre-amplifier features 2.5 dB noise figure

Communications preamplifier, model FW0811N, provides low-noise figure and group delay variation over 0.8-1.1 GHz. Typical performance figures are noise figure 2.5 dB, group-delay variation ±8 picoseconds and 20 dB gain. The amplifier has been designed specifically for communication front end applications, both in new equipment design and as a retrofit for tunnel-diode amplifiers. P&A: $220 in small qtys; stock to 4 wks. **Frequency-West, Inc., 3140 Alfred Street, Santa Clara, CA 95050 (408) 249-2850.**

READER SERVICE NO. 136

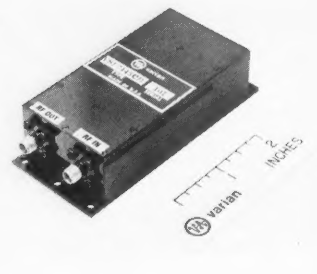
I-f preamplifiers have 1.5 to 4 dB NF

Series PE1171 low-noise i-f preamplifiers cover frequencies from 10 to 2000 MHz. Gain is 30 dB min. Noise figures are from 1.5 to 4 dB. Size is 3 in. × 1.5 in. × 1 in. & weight is 4 oz. Operating temperature from −55 to 85°C. P&A: $90; stock to 2 wks. **Pasternack Enterprises, 9562 Dumbreck Drive, Huntington Beach, CA 92646 (714) 962-8887.**

READER SERVICE NO. 108

AMPLIFIERS

Octave amplifiers deliver 25 dBm



Medium power solid-state amplifiers, models VSL-7445C and VSS-7455A, cover 1.0 to 2.6 GHz with 200 mW output and 2 to 4 GHz with output of 100 mW, respectively. Typical noise figures are 7.5 dB and 6.5 dB. Weight is 10 oz. **Varian, Solid State West Division, 611 Hansen Way, Palo Alto, CA 94304 (415) 493-4000.**

READER SERVICE NO. 119

Log amps have 25 ns risetime

Detector log amplifiers in the LD1100 series are designed to optimize log linearity over a wide dynamic range. Typical values are ±0.2 dB from near tangential signal level to 0 dBm and cover the range from 1.0 to 18 GHz. Self-compensating, balanced logging stages hold variations over temperature to within 0.75 dB (typical) over the range from −54°C to +71°C. LD1100 series detector log amplifiers have a max risetime of 25 ns, making them compatible with current system requirements for narrow-pulse processing. P&A: $750-$825; 30 to 45 days. **Aertech Industries, 825 Stewart Drive, Sunnyvale, CA 94086 (408) 732-0880.**

READER SERVICE NO. 114

MISCELLANEOUS

S-band varactors feature high Q

The silicon varactors in the GC-1800 series are abrupt-junction devices providing a min reverse breakdown voltage of 90 V at 10 μA max. Designed for use up to 4 GHz, these tuning diodes are used in circuits requiring a high Q varactor such as tunable filters and amplifiers, voltage-controlled oscillators and frequency synthesizers. They are also used as linear frequency and phase modulators in communications applications. **GHZ Devices, Inc., 16 Maple Road, Chelmsford, MA 01824 (617) 256-8101.**

READER SERVICE NO. 135

Waveguide switch protects transmitters

This series waveguide switch, No. 34C90400 WR-284, covers 2.6 to 3.95 GHz with a VSWR of 1.1 max, an insertion loss of 0.2 dB max and isolation of 60 dB min. It features manual actuation and a temperature range of −54°C to +95°C.

The switch can be ordered with an optional interlock feature that provides positive transmitter protection. When the actuation knob is turned, control contacts are opened before the waveguide rotor is moved. The contacts do not close again until the rotor is in its new position. Other models for WR-62 to WR-284 waveguide can be ordered. **Transco Products, Inc., 4241 Glencoe Avenue, Venice, CA 90291 (213) 821-7911.**

READER SERVICE NO. 126

Power transistors offer 70-90 % η

Rf power transistors, models TPT 1001 and TPT 1002, employ a continuous plate-like emitter, metal-base grid and centrally-located emitter bonding wires to achieve collector efficiencies ranging from 70 to 90%.

TPT 1001 and TPT 1002 are rated at 5-W and 3-W, respectively, at 400 MHz and 28 Vdc bias. They are hermetically sealed in a TO-60 package or can be ordered in a stripline design. **Transistor Power Technology, Inc., Douglas Hill, ME 04023 (207) 787-2020.**

READER SERVICE NO. 121

NEW PRODUCTS RELEASED AT PRESSTIME

Filters can be multiplexed

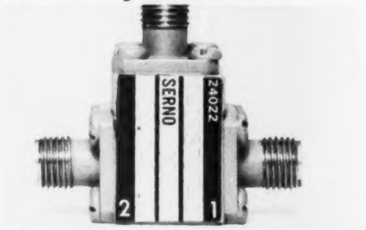
A series of microwave filters and multiplexers provide coverage from 100 MHz to 20 GHz as shown in the table.

Stopband rejection of 50 dB min is typical and insertion loss is 0.75 to 1 dB max. Passband VSWR is 1.4 to 1.6 max. Channel separation or combination may be effected by multiplexing two or more filters onto a single port using a common external junction. Crossover channel separation may be varied from being contiguous (at 3 dB frequency) to any desired attenuation level. **Frequency Contours, Inc., 3140 Alfred Street, Santa Clara, CA 95050 (408) 984-7820.**

READER SERVICE NO. 350

Model No.	*Passband (GHz)*	*Model No.*	*Passband (GHZ)*
FC-7101	0.5-1.0	FC-7107	7.0-11.0
FC-7102	1.0-2.0	FC-7108	8.0-12.0
FC-7103	1.6-3.2	FC-7109	8.0-16.0
FC-7104	2.0-4.0	FC-7110	11.0-18.0
FC-7105	2.6-5.2	FC-7111	12.0-18.0
FC-7106	4.0-8.0		

K-band circulators have only 1 dB loss



Circulator model C-18S33T covers the frequency range of 18-26 GHz. Isolation is 16 dB, insertion loss is 1.0 dB and VSWR 1.5:1. Package size is 0.68 x 0.51 x 0.53 in. Standard connectors are SMA female. **Teledyne Microwave, 1290 Terra Bella Avenue, Mt. View, CA 94043 (415) 968-2211.**

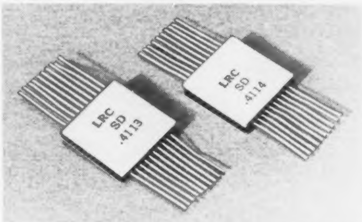
READER SERVICE NO. 351

4 GHz amps deliver 1/4 W

Medium power transistor amplifier, model VSG-7425F is specifically designed as a transmitting amplifier in commercial line-of-sight microwave systems. Power output is typically more than 250 mW. Frequency range is 3.7 to 4.2 GHz and min power output at saturation is +23 dBm. Typical noise figure is 8.5 dB and small signal gain is typically 37 dB. Weight is 10 oz and size is 1.0 x 2.5 x 4.25 in. **Varian, Solid State West Division, 611 Hansen Way, Palo Alto, CA 94303 (415) 493-4000.**

READER SERVICE NO. 352

Drivers turn on high V diodes in ns



Solid-state drivers, models SD-4113 and SD-4114, designed for use with high power diode switches drive two SPDT switches or four SPST switches, respectively. Both models, in flatpack configuration (0.650 in. x 0.650 in. x 0.150 in.) feature TTL compatible circuits. SD-4113 (driving two SPDT switches) provides inverting and non-inverting outputs. Model SD-4114 (driving four SPST switches) has inverting output. MIL-STD-883 screening is available. **LRC, Inc., 11 Hazelwood Road, Hudson, NH 03051 (603) 883-8001.**

READER SERVICE NO. 353

Linear power amps for CATV

Linear power amplifiers cover 30-300 MHz. Output power is +30 dBm min for 1 dB compression. Third-order intercept point is +42 dBm while input and output match is 2:1. Voltage is 20 V and current is 500 mA. Size is 7-1/8 x 2-5/8 x 1-7/8 in. P&A: $545. **Miteg, Inc., 100 Ricefield Lane, Hauppauge, NY 11787 (516) 543-8873.**

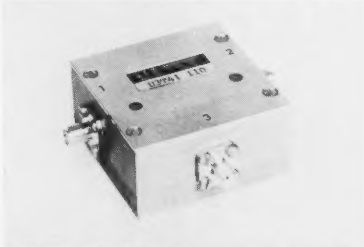
READER SERVICE NO. 354

5-550 MHz switch in dual inline package

Rf switch, model FD-1B, has an input frequency range of 5-500 MHz and output frequency range of 10 to 1000 MHz. Input power is +10 dBm while conversion loss is 12 dB. Fundamental frequency rejection is 20 dB min and temperature is −55°C to 100°C. P&A: $14.50; stock. **RF Power Labs, Inc., 11013 118 Place, N. E., Kirkland, WA 98033 (206) 822-1251.**

READER SERVICE NO. 355

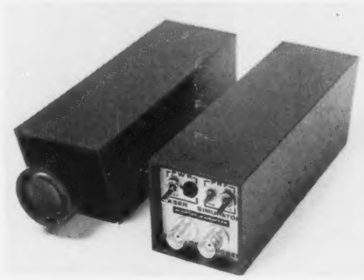
Uhf circulator measures 2" x 2" x 1"



Model U3T41 uhf coaxial circulator is designed for operation in the 300-500 MHz region. Bandwidth is 15% max while isolation is 17 dBm min. Insertion loss is 1.0 dB max and VSWR is 1.30 max. Rf power is 40 W cw and operating temperature is −30°C to +80°C. It is qualified to meet stringent MIL-spec environmental requirements. Vibration is 75 G's peak, 130 to 300 Hz and shock is 50 G's. Humidity is 90% RH at +60°C. P&A: $195 in qtys 1-5; 4-6 wks ARO. **E&M Laboratories, 5388 Sterling Center Drive, Westlake Village, CA 91361 (213) 889-1470.**

READER SERVICE NO. 356

Simulators check out laser seekers



Three laser simulators for rapid checkout of laser seekers and receivers are available. Model LS-1 operates at 1.06 microns and model LS-2 at 0.905 microns. They both have a 3 mW peak output and 20 ns pulsewidth. They also have a selectable PRF (single-shot, 10 pps, 20 pps). Model LS-3 has a wavelength of 0.660 microns, 3 mW peak output and 60 μs pulsewidth. It has selectable PRF (single-shot, 1 pps, 2pps).

Each weighs only 1 lb and can be used in the field or the laboratory to provide eye-safe pulses to simulate a variety of laser outputs. The unit is powered by a 9 V transistor radio battery that provides over 10 hours continuous operation. **Martin Marietta Aerospace, P. O. Box 5837, Orlando, FL 32805 (305) 855-6100.**

READER SERVICE NO. 357

new literature

Reprints

The article entitled "Simplify Switch Design with the Bosomworth Plot" which ran in the October 1973 issue of MicroWaves is available by contacting: **Robert P. Quinn, Varian Associates, 8 Salem Road, Beverly, MA 01915 and requesting Technical Paper reprint SSE201.**

Spectrometer

CT103 Spectrometer/Monochrometer is a computer-ready f/6.8 one-meter high-resolution unit. Included in the brochure is a detailed technical discussion of the CT103 features and accessories, plus complete specifications. **Chromatix, 1145 Terra Bella Avenue, Mountain View, CA 94043 (415) 969-1070.**

READER SERVICE NO. 170

Component Ovens

Fully proportional DC, AC Zero Crossing, and thermostatically controlled ovens for general components, crystals, microwave components, and high stability applications are illustrated. Temperature stabilities up to one half millidegree/°C. are shown. **Oven Industries, Inc., PO Box 229, Mechanicsburg, PA 17055 (717) 766-0721.**

READER SERVICE NO. 171

Noise Generator

These white noise generator diodes are hermetically sealed silicon devices operating in the avalanche mode and generating noise from frequencies of less than 1 Hz through the microwave region. Diodes are manufactured by a proprietary hybrid process that produces extremely high levels of noise relatively independent of frequency and temperature. White noise generator modules are hermetically sealed microcircuits utilizing proprietary voltage amplifier techniques coupled with white noise diodes. **Codi Semiconductor, Pollitt Drive South, Fair Lawn, NJ 07410 (201) 797-3900.**

READER SERVICE NO. 172

Laser Machining

CO_2 laser product line consists of models 42, 42L, 41 and 43 lasers, ranging from 50 watts to 500 watts in output power. They constitute safe and reliable sources of low, medium, and high power radiation, emitting at 10.6 microns. The CO_2 lasers provide flowing gas from either pre-mixed or separate gas bottles and are designed with generous power margins. They can be used for many applications viz: high-speed perforation of plastic, rubber and paper sheeting; the manufacture of steel rule dies for the carton packaging industry; cutting and welding of exotic aerospace alloys; resistor trimming, and scribing/drilling of ceramic substrates in the microelectronics industry. **Coherent Radiation, 3210 Porter Drive, Palo Alto, CA 94304 (415) 493-2111.**

READER SERVICE NO. 173

new literature

Trans. Lines

Data on rigid coaxial transmission line includes information on design and construction, plus a listing of availabilities in four sizes ranging from 7/8 to 6 1/8 inch either in 20-foot sections or special lengths which may be ordered with flanges both ends, flange on one end or without flanges. FM broadcast antennas are also described in this 22-page catalog. **Phelps Dodge Communications Co., Route 79, Marlboro, NJ 07746 (201) 462-1880.**

READER SERVICE NO. 179

Conversion Scale

A free conversion scale is available. It converts microvolts to dBm and vice versa. High resolution is afforded by the 10-inch scale length. It is printed on silver foil with adhesive backing suitable for permanent attachment to an instrument. Overall size is 11x1/8 inches. **Singer Instrumentation, 3211 South LaCienega Blvd., Los Angeles, CA 90016 (213) 870-2761.**

READER SERVICE NO. 175

Laser Brightness

Modular high-brightness laser systems are discussed with highlights of full specifications and typical configurations. It utilizes various combinations of proven modular oscillator/amplifier components; is tailored to meet the most exacting requirements-fully backed by applications engineering and maintenance service. **Korad Division of Hadron, Inc., 2520 Colorado Avenue, Santa Monica, CA 90406 (213) 829-3377.**

READER SERVICE NO. 174

Impedance Assembly

A level and impedance coordination assembly providing for interconnection of FDM multiplex equipment and microwave radio equipment with different impedances and/or levels is the topic of discussion in this short brochure. **Karkar Electronics, Inc., 245-11th Street, San Francisco, CA 94103 (415) 593-0326.**

READER SERVICE NO. 180

Photometer

A wide variety of accessories are available for this photometer. They increase the versatility, portability, convenience and field use. The accessories fall into five major classes: 1) optical accessories including 2 Cassegrain telescope objectives, color temperature iris diaphram, filter holder, external calibrating light source and Micro-Cell for adapting standard microscope objective to the photometer; 2) illuminance measuring accessories; including an illuminance baffle, cosine receptor, reflectance standard and fiber optics probe; 3) portable, rechargeable AC power supplies; 4) tripods, supports and X-Y translators and 5) foam-lined, impact-resistant carrying cases. **Photo Research, 3000 North Hollywood Way, Burbank, CA 91505 (213) 849-6017.**

READER SERVICE NO. 169

letters

On behalf of double-balanced mixer

To The Editor:

In The article, "New Mixer Designs Boost D/F Performance", (Oct., 1973, p. 60), important advantages of broadband double-balanced mixers were not properly presented: and the case for their use is far stronger than indicated. For example, several generalities were made that contradict practical measurements made by other DF systems manufacturers. Specifically, it was stated that certain restrictions (such as low rf VSWR, low LO VSWR, and image rejection at the rf port as described on p. 64), "rule out the doubly-balanced mixer and 180-degree hybrid mixers as contenders for broadband phase and amplitude tracking systems."

In contrast, we at RHG have found that it is better to insure the tracking of rf and LO VSWR as well as magnitude between mixers. This is a far more important criteria for insuring overall system amplitude and phase tracking. In addition, it would appear that a mixer with the simplest internal construction (i.e., *no* tightly coupled wideband hybrids) would offer the greatest potential for good phase and amplitude tracking. From a practical standpoint, it can be shown by independent users of double-balanced mixers that phase and amplitude tracking of ±3 degrees and 0.5 dB is possible from 2 to 18 GHz in a pair of mixers utilizing wideband microstrip baluns even though the input rf and LO VSWRs are typically 2:1.

With respect to spurious suppression, the following statement is made on page 68: "For example, a choice of mixers will not help the particular situation depicted in Figure 12, since all of the mixers suppress the 2 x 2 and none of them suppress the 3 x 3."

The former statement is quite true with respect to the LO power variations shown in Fig. 12 of the article; but again, there are practical limitations to be considered (particularly when comparing a 90-degree hybrid mixer with a wider band doubly-balanced mixer). The figure provided shows the variation with rf frequency of the 2 x 2 spurious product for a 90-degree, 2 to 4 GHz mixer (RHG model MP2-4) compared to the same spurious product measured from a 2 to 4 GHz doubly-balanced mixer (RHG model DM2-4). The wide variation of 2 x 2 spurious rejection with the 90-degree hybrid mixer over the band of interest is due in part to the high VSWR of the hybrid coupler at twice the applied rf and LO frequencies. (Note that the 3 x 3 product of the 90-degree hybrid mixer is more constant with frequency because the hybrid will work at three times the applied frequency.)

The spurious suppression, intermodulation products and two-tone third order interference in mixers are parameters of keen interest to system designers. However, all of these parameters are somewhat frequency dependent and depend upon the design and construction of the mixer used. For this reason, we believe that the system designer should be cautioned against using low frequency generalized tables of intermodulation products and extrapolating the performance to higher microwave frequencies. A safer procedure would be to predict intermodulation product levels from data taken directly at the frequency of operation.

Donald Neuf Mgr., MW Prod.
RHG Electronics Laboratory, Inc.
Deer Park, NY 11729.

And Author's Reply:

Mr. Neuff's concern regarding the most desireable mixer types for good phase and amplitude tracking receivers is understandable. First, I would like to correct the inference that the conclusions were arrived at on a purely theoretical basis. Anaren has recently published a 40-page catalog entitled, "Wideband Microwave Phase/Amplitude Tracking Receiver Front Ends." (For a copy check RSN #160).

Mr. Neuf states that low rf and LO VSWR's are not critical to amplitude and phase tracking, and if the reflection coefficients are matched in both phase and amplitude, then even with VSWR's of 2.0/1 (typical), receivers will phase and amplitude track. This may be true if they are the only mismatches in the system, then the receivers will track each other. In a real system, however, this is not the case, since antennas, filters, limiters, self-test devices, isolators, etc., typically precede the mixers. Can the mismatches from these devices be made to phase and amplitude track? If not, they will beat the mixer mismatches and cause serious phase/amplitude errors in the receiver-insertion characteristics.

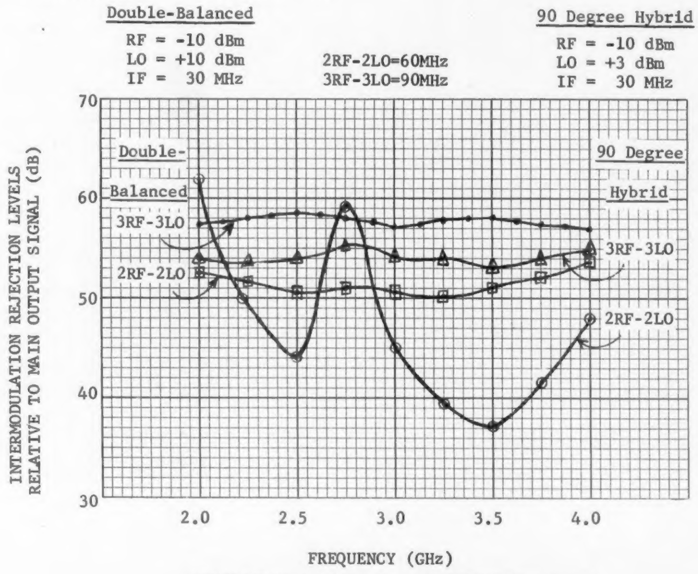
We have found that both in practice and theory, the double-balanced mixer and the 180-degree hybrid mixer have significantly inferior phase and amplitude characteristics as compared to either the 90-degree hybrid mixer or the quadrature-fed dual mixer (QFDM) when used in an actual system—particularly in the range 2-18 GHz where the VSWR of all components tend to degrade. (Incidentally, the table on pp. 62, 63 had an error in the VSWR column. The good and poor rating were reversed.)

Mr. Neuf also points out that "2 x 2 spurious rejection of the 90-degree hybrid mixer varies considerably with the band of interest. This is due in part to the VSWR of the hybrid coupler at twice the applied rf and LO frequencies." A properly designed 3 dB backward wave coupler has good VSWR which is independent of frequency up to the point where waveguide modes can be supported in the structure. I am not familiar with the type of quadrature coupled used in the RHG Model MP2-4; but if it is a backward wave coupler (as opposed to a branch line), then I do not think that his problem is due to the coupler.

At Anaren, we have found that the suppression of any spurious terms of a 90-degree hybrid mixer depend most strongly on the decoupling network behind the diodes and the operating point of the diode on the I-V characteristic. The 2 x 2 data shown by Mr. Neuf was obtained using LO levels of +10 dBm for the double-balanced mixer and only +3 dBm for the single-balanced mixer. We feel that +3 dBm is slightly starved for good 2 x 2 suppression in an unbiased 90-degree hybrid mixer.

I do agree wholeheartedly in Mr. Neuf's comments about not using low-frequency generalized tables and extrapolating to microwave frequencies.

Carl W. Gerst, Jr., Exec. VP
Anaren Microwave
Syracuse, NY 13205



COMPARISON OF 2X2 AND 3X3 INTERMODULATION PRODUCTS OF 90 DEGREE HYBRID AND DOUBLE-BALANCED TYPE MIXERS IN THE 2 TO 4 GHz BAND

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microwave product index

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305	315	325	335	345	355	365	375	385	395	505	515	525	535	789
306	316	326	336	346	356	366	376	386	396	506	516	526	536	790
307	317	327	337	347	357	367	377	387	397	507	517	527	537	791
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300	310	320	330	340	350	360	370	380	390	500	510	520	530	784
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306	316	326	336	346	356	366	376	386	396	506	516	526	536	790
307	317	327	337	347	357	367	377	387	397	507	517	527	537	791
308	318	328	338	348	358	368	378	388	398	508	518	528	538	793
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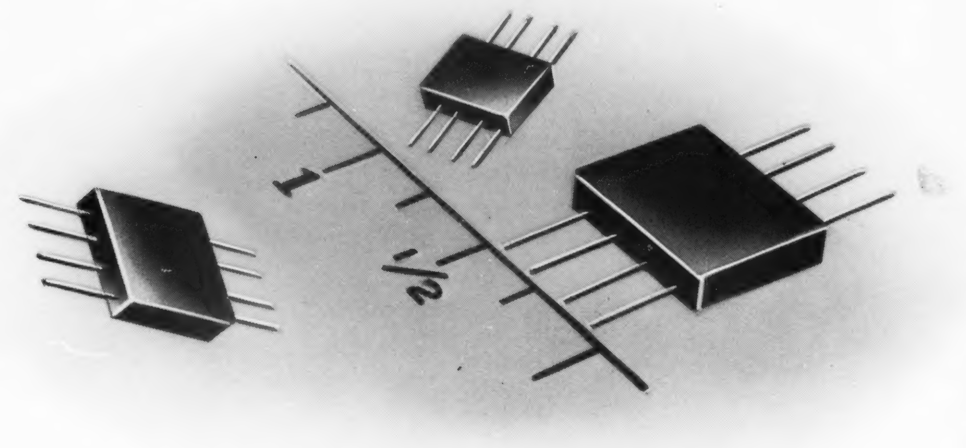
Merrimac's

FLAT PACK TEAM

Miniature Mixers, Quadrature Hybrids, and Power Dividers....

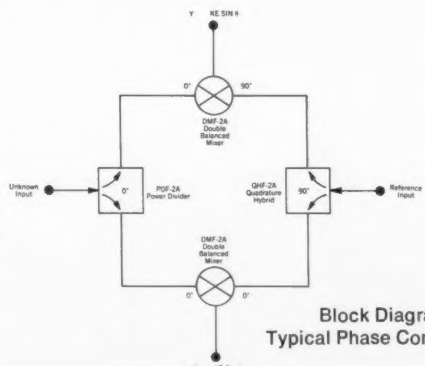


Now Merrimac offers a versatile lineup of miniature Flat Pack devices for mounting to stripline and printed circuit boards. These include PDF-2A two-way power dividers covering the 2 to 200 MHz frequency range, the QHF-2A quadrature hybrids covering center frequencies from 5 to 160 MHz, and the DMF-2A broadband balanced mixers covering the 5 to 1500 MHz range. Individually or as a group, these devices are ideal for space, airborne, ground, or shipboard applications where high density packaging is required.

....And How They Work Together

These three Flat Pack devices can be combined to form a miniature phase comparator which is unambiguous over the 0°-360° phase difference range (see diagram):

Two signals of the same frequency and amplitude, but differing in phase, are applied to the unknown and reference ports. A PDF-2A power divider splits the unknown input into two equal phase/equal amplitude signals. The reference input is split into two equal amplitude but quadrature-phased signals at the QHF-2A quadrature hybrid. Each DMF-2A mixer is then presented with two signals; the resulting outputs represent, respectively, the *sine* and *cosine* of the phase difference.



Block Diagram
Typical Phase Comparator

For more details on these or other Merrimac Flat Pack products, contact Merrimac today.

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